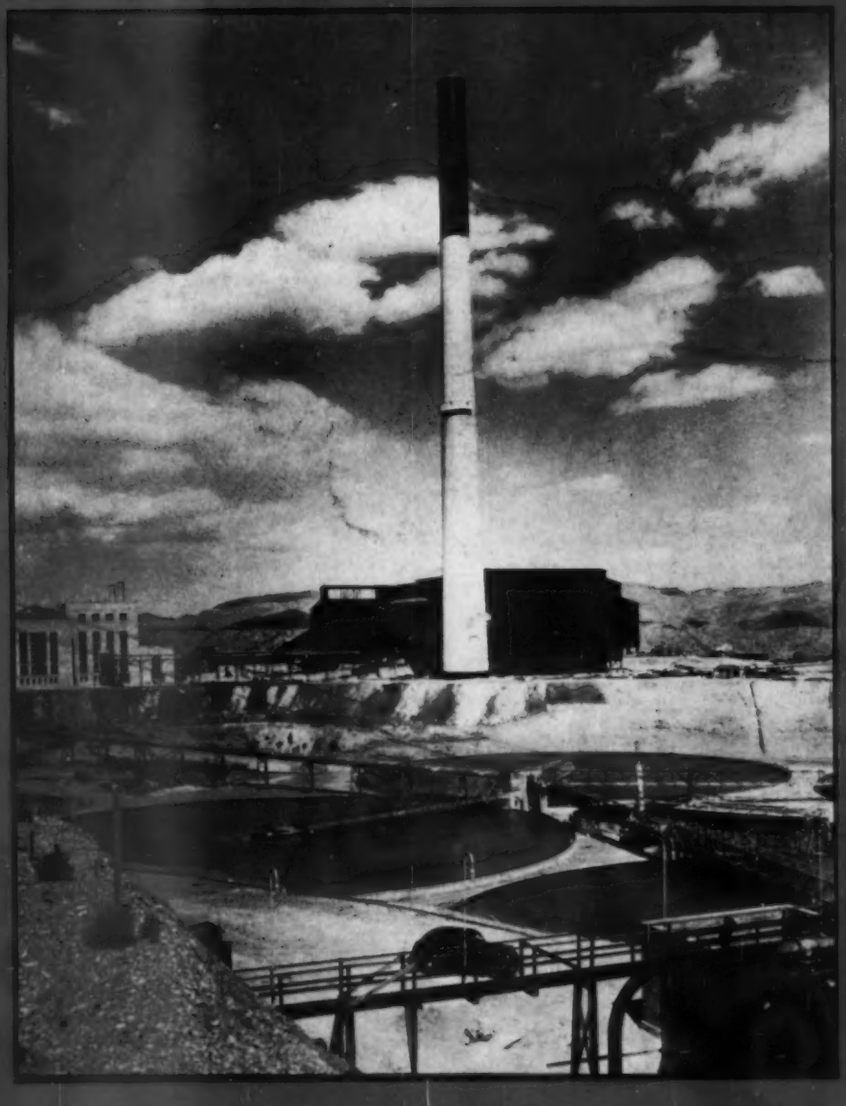
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

August, 1942



New power plant and waste-heat installation at a large copper refinery in the Southwest.

Power Plant Piping and Problems ▶

Increased Stress Allowance For Boilers ▶

why Jimmie Fowler of C-E's drafting dept. re-named the VU steam generator

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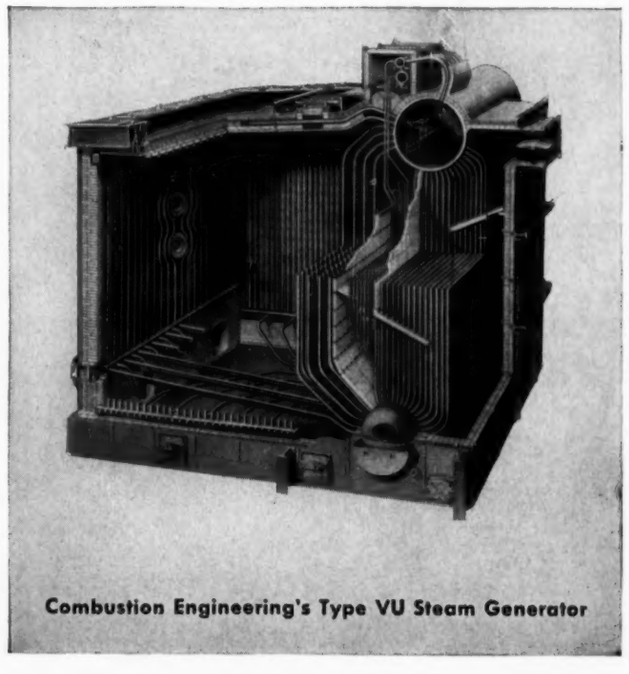

Combustion Engineering's Type VU Steam Generator

COMBUSTION ENGINEERING

200 MADISON AVENUE, NEW YORK, N. Y

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME FOURTEEN NUMBER TWO

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Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Avenue, New York
A SUBSIDIARY OF COMBUSTION ENGINEERING COMPANY, INC.

Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer.

COMBUSTION is sent gratis to engineers in charge of steam plants from 500 rated boiler horsepower up and to consulting and designing engineers in this field. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents.
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Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York CCA Member of the Controlled Circulation Audit, Inc.

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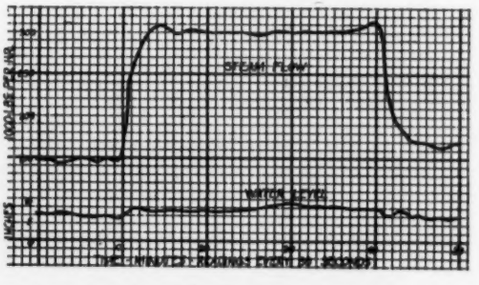

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EDITORIAL

Standardization, Now and Later

In order to conserve materials, to simplify production methods and to increase productive capacity, the War Production Board is working with the American Standards Association for the further development of war standards covering types, sizes, dimensional uniformity, interchangeability of parts, material specifications, ratings of equipment, methods of test and rules of operation. Although the efforts so far have been directed largely toward domestic appliances and consumer goods, the lists are being expanded to include certain industrial equipment. For instance, a recent WPB order prohibits the production of machine tools that call for special electrical specifications and makes it mandatory to conform to the 1942 Machine Tool Electrical Standards covering the drive and control of such machines. Also, the WPB has recently requested the standardization of industrial equipment instruments as to types, sizes, mountings, etc.

As for power requirement, there has been a noticeable trend during the present emergency toward the use of more or less standardized designs of proved performance and less variety in sizes and steam conditions, in order to lessen the engineering involved and speed deliveries.

While the exigencies of war render standardization imperative in many lines, one may well cogitate as to how it is likely to be affected by post-war conditions. To what extent will the fruits of wartime research influence future practice? Will the abundance of certain materials, born of wartime needs, lead to replacement of other long-used materials? If so, entirely new specifications and standards will become necessary. And, finally, will the pent-up inventive genius of American engineers emerge in the form of new designs in the quest of still better performance?

These are all factors that make for progress and they are likely to affect post-war practice in many fields; but, despite this, the present advances in standardization will have left their imprint.

In the power plant field the situation may perhaps be somewhat different. It will be recalled that prior to the last war, power plant practice had been more or less static for a number of years and the time was ripe for the innovations of the early twenties. On the other hand, the present war follows a period of unprecedented advance in power plant practice and it is possible that the period immediately following its termination may witness the consolidation of gains of the last eight or ten years, and that economic considerations will exert greater influence on design.

Standardization, if established prematurely, can become a deterrent to progress, and there is likelihood that some, resulting more from war expediency than from maturity of development, may be in this category. However, in the power plant field there has been an appreciable trend toward standardization for several years past, notwithstanding the many new designs evolved; and it is altogether probable that this trend, accelerated by war practice and post-war economic considerations, will continue on an increasing scale, with new developments directed more toward improvement in details.

An Outstanding Station

The very large power station has so long been associated with American practice that, aside from a few notable installations in England and on the Continent, one is inclined to lose sight of what has been transpiring in this respect in some other parts of the world. A case in point is the Klip steam generating station of the Victoria Falls and Transvaal Power Company, near Johannesburg, South Africa. This plant, construction of which was begun eight years ago and the first unit of which was put in operation in 1936, has been progressively extended until it now has a total capacity of 424,000 kilowatts. This comprises twelve 33,000-kilowatt turbine-generators and four 7000-kilowatt auxiliary sets, supplied with steam by twenty-four stoker-fired boilers. The extent of the plant may be visualized by the fact that the turbine room alone is 819 feet long by 100 feet between crane centers. A unique feature is that this vast capacity is served by a series of ten concrete cooling towers and coal is delivered directly from the mine to the bunkers.

According to a report published in *Engineering*, of London, the 1940 output of this station exceeded $2^1/_2$ billion kilowatt-hours, which was more than double that of any British station. Moreover, it operated at an annual load factor of over 80 per cent—a figure which few, if any, American steam stations can boast. This, of course, is attributable to the character of the load which is made up largely of mining operations. It is probable that, because of war conditions, the output may have increased still more by this time and the load factor may have been still further improved.

Aside from the fuel supply and the handling of condensing water, both of which are dictated by local considerations, a point of marked difference between this plant and later American stations is the employment of a greater number of units of moderate capacity and relatively low steam conditions, namely, 345 pounds pressure and a temperature of 734 F. There were undoubtedly well-founded reasons for such selection, but it is to be regretted that the report as printed did not contain performance figures so that some comparison might be made with other large stations employing more advanced steam conditions and larger individual units.

Power Plant Piping and Piping Problems

By H. F. BEHRENS

The Commonwealth & Southern Corp., Jackson, Mich.

A practical and detailed discussion of the piping such as would be employed in a steam power station designed for a medium pressure of around 900 lb and 900 F total steam temperature. The discussion covers the main steam lines, small high-temperature piping and fittings, flanges, bends, hangers and connections for blowdown, feedwater heaters, evaporators, circulating water lines, ash handling and fire protection, as well as welding.

PIPING design has been the subject of many technical papers during the past decade, but it is felt that some of these have failed to serve the intended purpose because they were too general. While piping, wherever it is installed, has a definite relationship to other piping, the problems, codes, materials, etc., involved in each case are such that designs must differ. The present discussion will deal with only the piping and piping problems of a steam power plant designed to operate at about 900 lb, 900 F.

In order that the reasons for the type of design may be better understood, two diagrams have been included to show the schematic arrangement of the equipment and piping. These diagrams are made after the pattern of the heat balance diagram and are completed to show the general characteristics of the major equipment being installed. Piping diagrams must also show conditions that are inherent in a plant site; namely, circulating water elevation and variations, origin of the cooling water, makeup water, drinking water, etc.

By having the piping diagrams complete in all details rather than partial diagrams, the drafting may be expedited by working on many lines concurrently. The grouping of pipes in a pipe gallery does not accomplish the desired results of making it more accessible. Piping run directly from one connection to another by the shortest route really makes the lines more accessible and decreases the cost, but it results in piping being located in all parts of the plant except the electrical rooms. In separating the various lines in that manner it is less difficult to provide the necessary room for insulation. Flexibility must not be overlooked while keeping the lines short.

Head room in the passageways is a point that cannot be stressed too strongly. The pipe designer should try to maintain at least seven feet from the floor to the underside of the pipes or flanges, using six feet six inches as the absolute minimum. No pipes should be run on the floor at any point in the plant. The valves should be so located as to give the maximum amount of accessibility for operation and repairs. If necessary, chain wheels or extended stems should be provided. In making a piping drawing, the handwheels and stems of all valves should be shown to avoid interferences with other piping and equipment. The pipe connections on the equipment must be checked by the field engineer and the equipment set to very close tolerances. This insures a good fit of the prefabricated piping. Common practice is to give the main steam, feedwater, circulating water and atmospheric-relief piping right of way and locate other piping where possible.

This paper will deal with piping that is shop fabricated completely from the engineers' drawings and erected by the equipment or pipe erection contractor. Piping can be engineered, purchased and erected in countless ways, but it is believed that the best results are obtained at the lowest cost by having engineering done completely by the power plant designer rather than by the pipe contractor.

Carbon-Molybdenum Pipe for Main Steam Lines

Due to the long delivery required for carbon-molybdenum pipe, it is advisable to order the large piping material ($2^1/_2$-in. and over) from the mill twelve to fifteen months before it is required in the field. This requires that the high-pressure and high-temperature piping drawings be made up complete, with exception of the field weld locations, a year before they are required in the field. Field welds are located after the mill length is determined.

Carbon-molybdenum valves, etc., should also be purchased on long delivery. The use of welding fitting and special carbon-molybdenum fittings should be avoided. Pipe can be purchased direct from the mill or through a piping fabricator. The total cost of carbon-molybdenum pipe after fabrication is about the same in either case because the fabricator will add a handling charge of about 25 per cent of the cost to the purchaser's pipe for his protection against possible damage and loss of material. Pipe purchased direct from the mill may be given a very rigid inspection, including microscopic grain structure examination, by the purchaser or may be purchased subject to the tests required by the A.S.T.M. Specifications, in which case the tests will be routine by the steel company. A certified copy of the tests may be obtained upon request. Pipe purchased without a mill inspection by the purchaser should be inspected for wall thickness and wall flaws at the fabricator's plant in time to permit replacement in case of rejection.

Small Piping for 900 F

It is difficult to determine in advance the exact amount of small high-temperature pipe required so as to give the mill sufficient time to make delivery. It is also

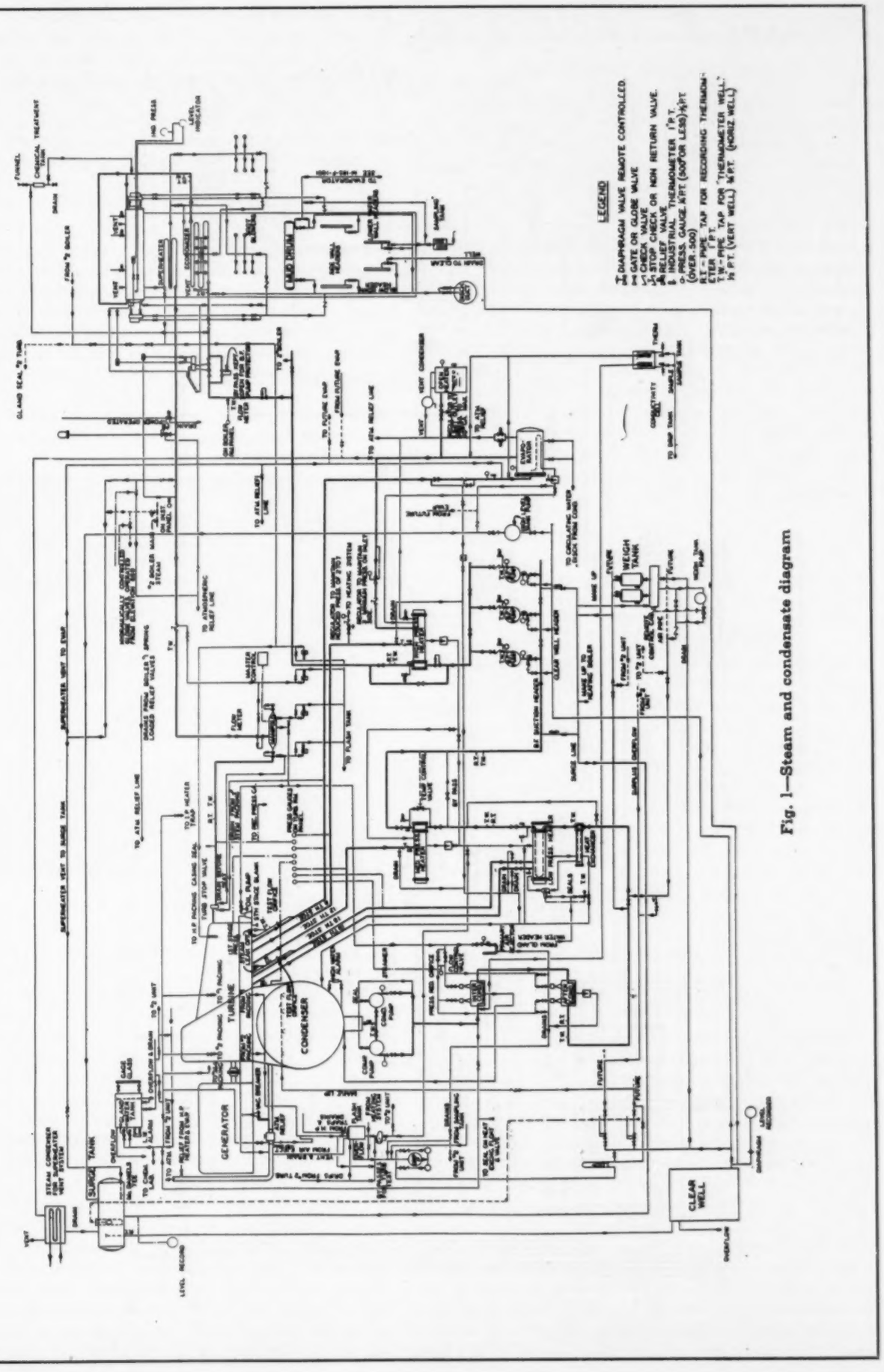


Fig. 1—Steam and condensate diagram

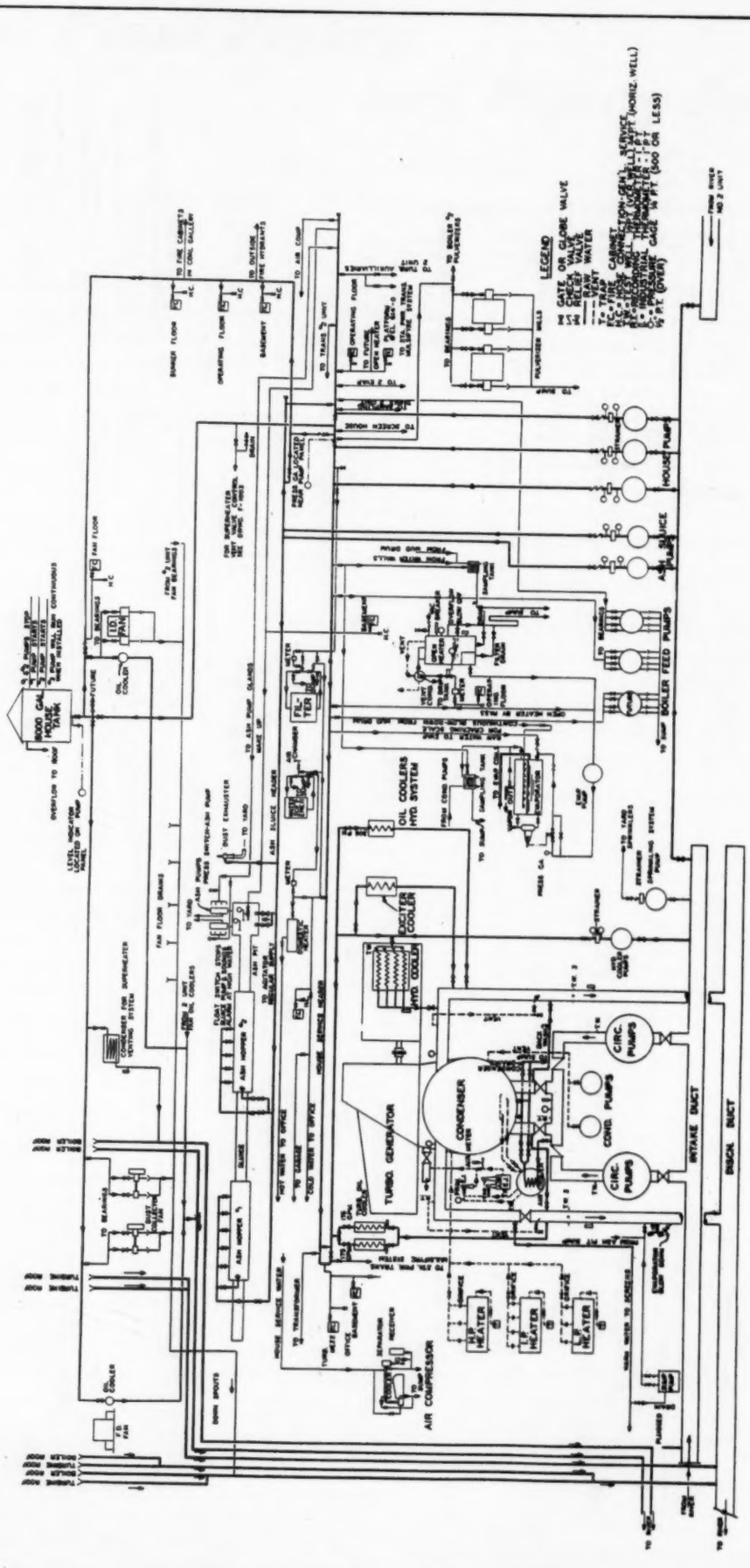


Fig. 2—Raw-water and air diagram

difficult to identify carbon-molybdenum pipe by visual inspection in the field or at the fabricator's shop. If carbon-molybdenum pipe is specified and one small section of carbon-steel pipe is slipped in, the whole system is no stronger than the section of carbon-steel pipe. Therefore, it is good practice to use carbon steel pipe for such service at an adjusted rating. This will result in the use of heavier wall pipe that can be identified with ease.

Small High-Pressure Fittings

Socket welding fittings have met with favor by some engineers, but it would seem that too much emphasis may have been placed upon the fact that no threading of pipe and no screwing of joints are required. It is difficult for a welder to hold a small fitting on the end of a pipe while welding, keeping the fitting outlet pointing in the right direction and also maintaining the $^1/_{16}$-in. space between the fitting and pipe end, as required by the Boiler Code, P-112.

It is therefore recommended that screwed steel fittings be used, and that the joints be made up without

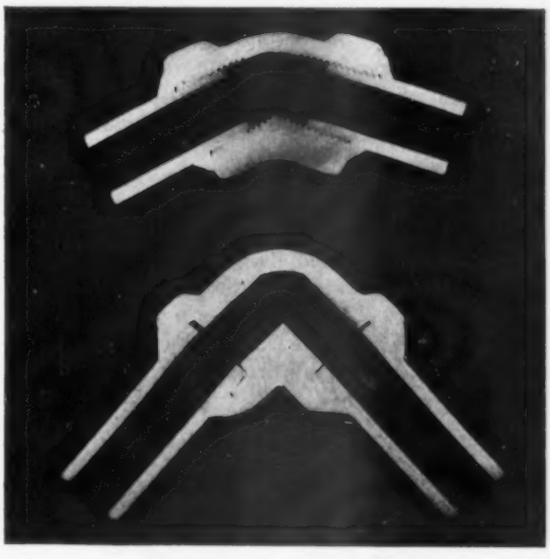


Fig. 3—Small pipe fitting

compound for this may interfere with the seal welding. The threaded joint will give the required strength against a complete failure, while the seal welding will insure a leakproof joint. Fig. 3 illustrates a good screwed joint and a poor socket-welded joint. A good welder is required so that only one or two beads may be used for seal welding. Arc welding should be used to keep the heat in the joint as low as possible. This type of joint, that is, screwed and seal-welded, is recommended for all high-pressure drip, drain, instrument piping, and bypass lines where changes in temperature may cause leaks.

Screwed Unions

In order that the small piping shall present a neat appearance, it is desirable to use screwed unions on sizes below 1 in. However, screwed unions should be purchased only by catalog figure number because there is nothing in the fitting catalogs of different manufacturers that varies as much in size, strength and weight for recommended pressures as screwed unions. Even the best screwed union should not be used for more than one third of the manufacturer's recommended pressure.

High-Pressure Feedwater Piping

For feedwater, A.S.T.M. 106 Grade A pipe is used and this is stocked in all weights by good pipe fabricators. Grade A is preferred over Grade B because the latter material requires a long delivery and cannot be identified from Grade A by visual inspection. This also applies to weld ells. They are purchased Grade A of the same wall thickness as the pipe. Unlike the main steam piping which is all-welded, the feedwater piping system has flanges on the pump discharge, heater inlet and outlet and both sides of the feedwater regulator. The balance is shop and field welded. A weld neck or lap flanges are used wherever a flange is required. All flanges are smooth faced. No welding tees are used because several extra butt welds are required and a nozzle or branch weld can be made to be just as strong. Gaskets in the feedwater lines have not presented a major problem, although failures have been experienced with monel metal gaskets, both flat and corrugated, due to uneven Brinell. Soft-iron gaskets also have failed due to the corrosive action of extremely pure water. Solid copper, filled copper and Flexitallic Style G-G gaskets have all given good results. The last mentioned has a retainer ring which prevents crushing the gasket due to uneven bolt stress. Gaskets used under safety valves on the boiler and superheater have given no trouble regardless of type or material used.

High-Pressure Valve Bonnet Leakage

Unlike the line gaskets that have given trouble only on feedwater piping, the bonnet gaskets have given trouble only on steam systems. This trouble has been mostly in connection with high-pressure gate valves subject to a large temperature change such as is experienced while getting a boiler on the line, or, in case of a dead-end valve, hot on one side and cold on the other. All makes of valves and types of gaskets have suffered alike, including the ring-type gaskets given preference in the Boiler Code. Most valve bonnet leakage was on gate valves installed in vertical lines. To a large extent this has been corrected by providing a drain from the valve bonnet into the pipe leaving the underside of the valve. In this way the bonnet is drained and kept at the same pressure and temperature as exists in the pipe leaving the underside of the valve.

High-Pressure Welding

Only qualified welders, certified by the insurance company, should be permitted to weld any pressure piping either in the shop or field. Inspection of welding by purchaser's engineers is required and no X-ray examination of the weld is made. If an X-ray inspection is felt desirable, it is made at the purchaser's expense. A careful check of the welder's qualifications is made before he is permitted to start work. If it is felt advisable, test coupons are made in the presence of the purchaser's engineers and at the purchaser's expense. The use of an Arcronograph or similar instrument to record the flow of the welding current is required on all high-pressure welding. This is not to determine the quality of the weld but is a check on the ability of the welder. Predictable results as to the physical properties and soundness of a weld can be secured only by following an approved pro-

cedure under which the welder has been certified. Good material as well as first-class equipment are of prime importance. Faults in material and equipment will show up on the record of the Arcronograph even with the best welder.

Nozzle Welds

Nozzle or branch welds should be made only in the fabrication shop and never in the field. The laying out and fitting of a branch connection requires accurate workmanship that makes it an art for only the experienced workman. This type of workman or suitable conditions are not found in the field. Angle branches should be avoided wherever possible and should never be used on high-pressure work where reinforcement is required. An angle branch of 45 deg or less requires the removal of too much material from the line pipe and makes an impossible welding condition in the crotch of the union. Of the three ways of cutting a nozzle into a pipe run, the method shown on Fig. 4 is preferred whether reinforced or not, because the nozzle weld end must be made to fit only to the outside diameter of the run pipe. This results in the removal of a smaller amount of material from the header and keeps the welding out in the open, rather than down in a valley where the work is hard to see and clean. As a result of the advancement in the art of welding and the ability to determine a good weld without the use of destructive tests, nozzle welding has found universal favor among piping designers, in place of welding tees, but the design and execution is much too difficult to attempt in the field. Where field-welded branch connections are necessary on high-pressure systems, especially when the branch approaches the header size, the use of welding tees is recommended.

Reinforced Nozzles

Much has been written about reinforced nozzles of all descriptions, but very little has been written on the method of calculating the exact amount of reinforcing required. The A.S.A. Code on pressure piping does not cover the subject of nozzles on pipe, and the A.S.M.E. Boiler Code and the A.S.M.E. Unfired Pressure Vessel Code cover only reinforced nozzles as applied to vessels of large diameter as compared with the size of the attached nozzle. As a result, pipe designers have for some years, since the use of welding has become rather common, been more or less guessing at the amount of material to be added. Also, the type and location have been somewhat of a guess. The pipe designer's position was much like that of the concrete designer when reinforced concrete was first coming into common use. They knew that reinforcing was necessary, but how much and where, they were not too sure. The only complete data on calculating reinforcing nozzles that has come to the writer's attention were contained in a paper prepared by F. C. Fantz and W. G. Hooper which appeared in the February 1940 issue of *The Welding Journal.*

There have been many types and methods of reinforcing suggested in various technical papers and many elaborate tests have been run to prove one method of reinforcing superior to another, but these tests, as elaborate as they were, all failed to duplicate actual field conditions in that they did not take into account the stresses resulting from expansion forces in the piping system. The old idea of providing gusset-plate reinforcing gave stiffness to the nozzle, but no pressure reinforcing to the header from which material had been removed. The newer idea of ring reinforcement provides for the pressure stresses, but not for the expansion forces. It is for that reason that a standard design of saddle with a collar on the branch is preferred. On the 900 F steam nozzles, cast carbon-molybdenum saddles are used, and on the feedwater, heavy forged carbon-steel saddles are used (see Fig. 4).

Flanges

The writer prefers to eliminate flanged joints wherever possible; also, to keep the field welding at a minimum. This makes it necessary for the designer of the piping to take the total cost of the flange or weld and insulation into account when making his decision on the use of flanged or welded joints. It would be hard to justify the use of Van Stone flanges for any service, if price only were considered, but a Van Stone flange has a large amount of flexibility that may be very desirable in field erection. If the pressure is 400 lb or over, Van Stone or weld-neck flanges are recommended; whereas, if the pressure is below 400 lb, screwed steel flanges, made up in the shop, or Van Stone flanges where flexibility is required, are preferred. Slip-on flanges are usually considered too expensive to permit their use for low-pressure service. This type of flange is limited by the Code for Pressure Piping to services of 300 lb per sq in. when welded front and back. A check on the cost of a slip-on flange, made on, will show it to be the most expensive type of flange for low-pressure service. When comparing the cost of a field-welded flange against the cost of a flange welded in a fabricator's shop, the overhead must not be overlooked. The fabricator's overhead is in his cost to the purchaser. The weld-neck flange is the lowest price welding flange for all around service because only one butt weld is required.

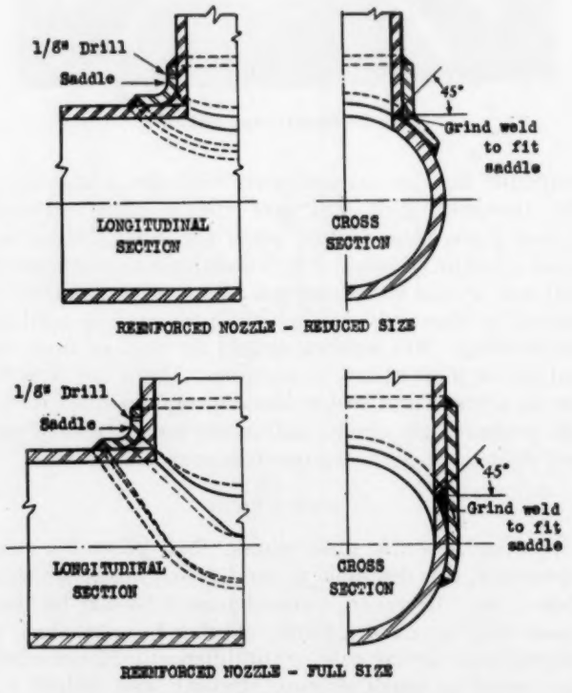


Fig. 4—Nozzle or branch welds

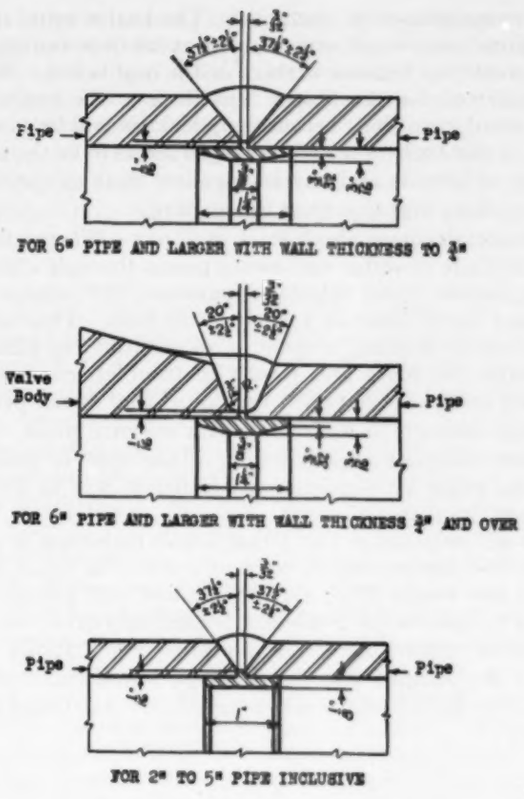


Fig. 5—Butt welds

Bends

In changing the direction in a run of pipe, either a fitting or a bend may be used, but like a branch connection or tee, the cost of insulation must be taken into account. If a check is made of the total cost of a bend against a fitting, it will be found that the pipe bend is the cheapest, with the welding fitting second and screwed steel flanges third. Note that screwed fittings are not taken into account because they are considered unsuited for power plant services. Bends also give a neater appearance, more clearance and greater flexibility.

Butt Welds

Butt welds are the easiest welds to design or make either in the field or shop, and therefore, any one of many designs may be used and still maintain the same factor of safety. Backing rings are desirable on high-pressure work both in the shop and field to be sure of 100 per cent penetration and to keep the pipe free of globules of weld metal that may become loose in operation and damage the valves or equipment. Of the many types of backing rings, the flat ring with a centering bead is preferred (see Fig. 5). This backing ring when properly fitted gives enough insertion into the pipe ends to prevent slipping during erection, and the small centering bead gives the required spacing of the welding groove. A good weld will penetrate into the ring well beyond the base of the bead so there need be no fear of a poor weld as a result of the bead. Some designers prefer six small pins for spacing the pipe ends, instead of the continuous bead. This is all right on a well-fitted ring, but the cost is slightly more. In choosing a backing ring, not too much emphasis should be placed upon the reduction of the inside diameter due to the thickness of the ring, but rather the pipe wall thickness at the weld should receive prime consideration. A recessed backing ring is not desirable because full (not minimum) pipe wall thickness is preferred at the weld. The pipe ends may be upset to give full wall thickness but this is expensive procedure. The welding groove may be of several types but care should be used to keep the groove open enough at the bottom to permit good welding and inspection at the root, and closed at the top to keep the welding at the minimum. Fig. 5 shows commonly used and preferred types of grooves.

Sandblasting

Shop-fabricated piping, particularly welded and stress-relieved sections, should be sandblasted or power-driven brush-cleaned on the inside to remove all scale (mill and shop) and weld metal, to prevent damage to valves or to the turbine. Due to the high temperature required for bending, bending sand often becomes glazed onto the inside of a pipe bend, and if it is not removed, trouble from this foreign material may result in the valves and turbine a year or more after installation.

Hangers, Anchors and Sway Rods

In feedwater piping, and more especially high-temperature steam piping, the flexibility must be checked very carefully and necessary bends provided to allow for forces and stresses. Spring hangers, anchors and sway bracing must be installed to guide the pipe movements to keep the forces at the desirable locations as well as to keep down the vibration. Ready-made hangers can be purchased that will give a uniform loading on the support and still allow the pipe to move as desired, or spring hangers may be designed that are not so complicated but serve the purpose equally well. Except in rare cases, it is not necessary to keep the load on the supporting structure uniform. Where this is desirable, a prefabricated hanger may be purchased, or if room is available, a counterweighted support may be designed. A counterweight hanger is sometimes the answer where the vertical pipe movement is large.

Boiler Blowdown and Drains

In the plants considered, only about 0.5 to 1.0 per cent evaporated makeup water is used with no feedwater treatment whatsoever. As a result, the boiler water concentrations build up very slowly. Therefore, the main blowdown valves are used only as boiler drain valves. The blowdown or drain is connected both to the river and clear well. The water is drained to the clear well if it is decided that the water is pure enough to save. This sometimes happens when the unit is being started after inspection. The connection to the river is used for wasting dirty water or for blowdown in case of high boiler water. The connection to the river is usually made into the circulating water discharge tunnel through a suction fitting of special design (see Fig. 6). The jet from this nozzle produces a suction that draws the river water up past the nozzle, thereby cooling the blowdown below the flash point. This type of installation is safe for 900 lb blowdown, free from noise, water hammer and corrosion. There is no vent or vacuum breaker on this blowdown system. If after a long period of operation, the solids

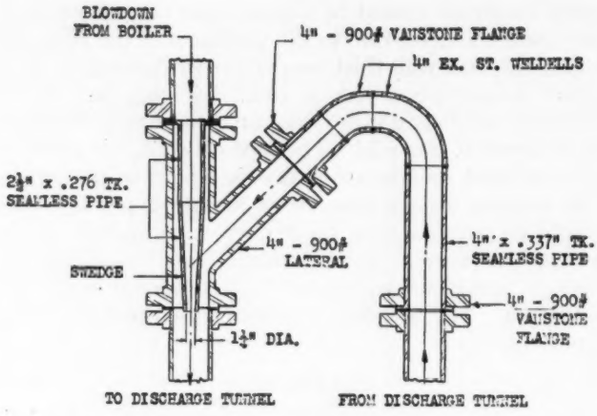


Fig. 6—Boiler blowoff connection

build up in the boiler water, a $^1/_2$-in. blowdown line connected to the evaporator open heater is used to bleed a small amount of water from the boiler continuously until the concentration is lowered. The solids in the boiler water build up slowly from the small amount of carryover from the evaporator, which seems to persist to a small degree in spite of corrective efforts. Condenser leakage adds some but this is detected immediately through the conductivity recording meter in constant use on the condensate. Repairs to the condenser can be made during operation by taking one-half out of service and operating with the other half.

Soot Blower Piping

There is nothing unusual or difficult about soot blower piping. When steam of high initial pressure is used, it is desirable to employ small pipe to get as much pressure reduction and flexibility as possible. Good drainage and a tight shutoff valve are necessary. A leaking valve permitting a stream of extremely pure condensate of rather low pH value, in the presence of oxygen, will soon cut a groove through the bottom of a horizontal run of pipe. Therefore, the shutoff valve should be kept as near the boiler as possible so there will be no reduction in temperature of the valve after the system is shut off, which will tend to prevent valve leakage.

Heater and Evaporator Piping

It is important that the venting of closed feedwater heaters be given special consideration in plants where the O_2, CO_2 and NH_3 are to be removed from the condensate without the use of deaerators (see Figs. 1 and 2). It is best that the heaters be vented direct to the main condenser and not through the consecutive heaters to the condenser. Since most of the CO_2 and NH_3 originates in the evaporator, the high-pressure heater which serves as the evaporator-condenser should be vented to the evaporator feedwater heater while the evaporator is in operation. The heater vents must be fitted with small orifices to prevent over-venting to the condenser because in this case the heat is lost. Brass is preferred for the heater vent lines to the condenser to retard corrosion, because any leakage will be inward and is not easily detected. Oxygen seems to be the main cause of trouble and any leakage lets more oxygen into the system, and this must be removed.

Heater drainage also has its problems. When a flashing mixture of water and steam passes through a throttling drainer valve to a lower pressure, the volume increases many times as a result of the flash. The energy released by flashing is spent in accelerating the mixture through the pipes and results in troublesome erosion. Better results are obtained with pipes that do not permit a large amount of flash than with oversize pipes. For a more complete understanding of this type of erosion, see the paper by Benjamin and Miller, A.S.M.E. *Transactions*, January 10, 1942.

It will be noted in Fig. 1 that a heat exchanger is used after the low-pressure heater to recover as much heat from the heater drips as possible and still permit the drips to flash in the condenser hotwell and drive out the occluded gases. However, on some installations, the drips are pumped into the condensate line and thereby all of the heat in the water is saved. It was found that

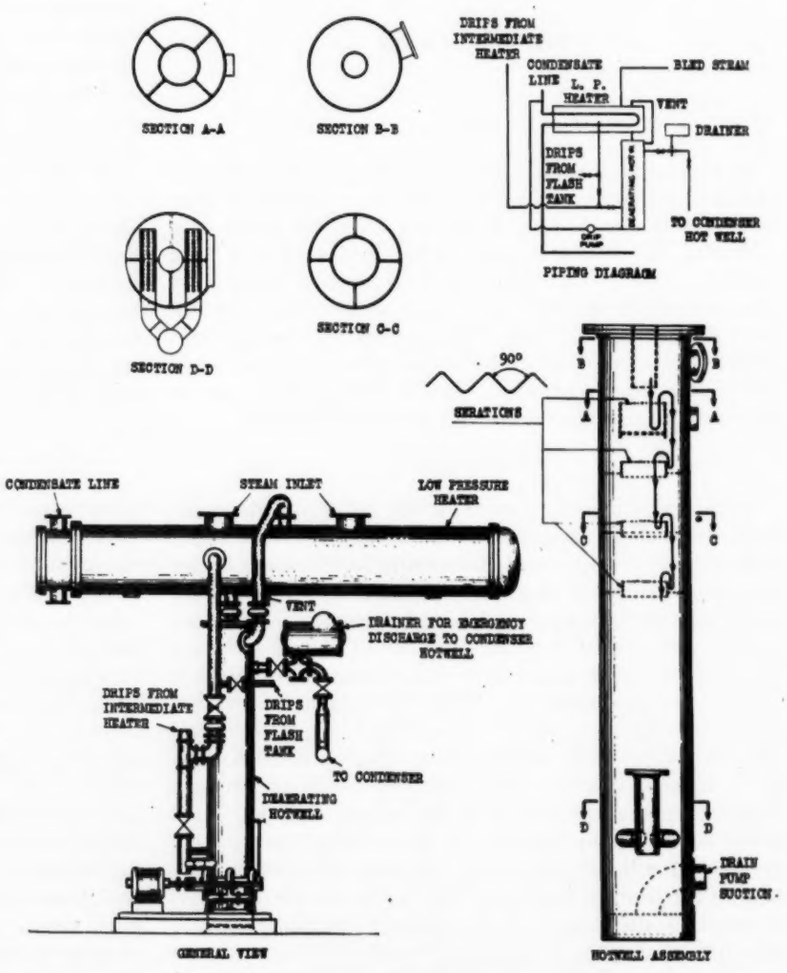


Fig. 7—Deaerating hotwell

these drips sometimes contain too much CO_2 and C_2 to be used as feedwater, and a drip deaerator was designed as shown on Fig. 7. These units reduce the CO_2 and O_2 to zero at all loads. This is done by flashing the drips of the intermediate heater into the bottom of the deaerator where the flash steam must pass through the falling drips from the low-pressure heater. The occluded gases are thus driven back to the low-pressure heater until they are removed by the heater venting system.

Ash Handling

Ash-handling piping will always give some trouble due to wear, but this trouble can be kept to the minimum by using cast alloy-steel pipe on the dry-dust lines and cast iron on the ash-pump discharge line. Dry fly-ash systems, where the dust is transported with air drawn by a hydro-jet, require the use of very hard material in the pipe and fittings. For that reason, neither carbon steel nor cast iron give good service. The material used should be uniformly hard and not just surface hardened. Plants where dust collectors are installed, having large fly-ash storage tanks, can be improved by eliminating the dust tanks. This can be done by installing a continuous dust-handling unit as shown in Fig. 8. This cyclonic mixer receives the dust continuously through the top opening directly from the dust collectors. Water is supplied through the three tangential connections on the enlarged section near the top. The centrifugal motion given to the water keeps it to the outside of the race until it overflows down the vertical sides of the bowl. By keeping the water from splashing as it enters the top of the bowl, the end of the dust pipe will be kept dry. This is important because the dust will build up very rapidly on this pipe and eventually give trouble if a small amount of water is present.

The water used for this unit is taken from the fan bearings and oil cooler if a hydraulic coupling is used on the fan drive. Any waste water can be used just as long as the supply is located high enough to flow to the cyclonic mixer. The mixer must be located high enough in the plant to have the falling slurry produce a suction of sufficient magnitude to overcome the maximum induced-draft-fan suction. The falling slurry must also flow by gravity to the ash-disposal pit. In using waste water, it is important that this come from a closed system because any air drawn through an open funnel or pipe will cause the water to splash in the mixer and wet the dust pipe. If cooling water, as suggested above, is used the flow through the cooler must be continuous and therefore a bypass must be provided so as not to interfere with the flow of cooling water when the mixer is taken out of service for inspection or cleaning, which has been advisable from once a day to twice a week. Common black steel pipe can be used for the slurry discharge because the mixture is not corrosive and the wear is slight.

Safety Valve Piping

The popping of boiler safety valves cannot always be avoided, and after a valve has opened several times, or even once, it is liable to leak. Because boilers once put on the line are kept there from four months to a year, leaking safety valves cannot be tolerated. Therefore, one large capacity safety valve, in addition to the Boiler Code requirements, should be placed on each large steam generator. This is usually a power-operated type of valve and is set low so as to open before any of the other valves. A gate valve is installed between this safety valve and the superheater header and in that manner the safety valve can be taken out of service at any time for regrinding. This design is rather common in large steam power plants but is not practiced to any great extent elsewhere. The occasional opening of a large high-pressure safety valve will give even the seasoned operator a start and has resulted in construction workmen jumping from high places.

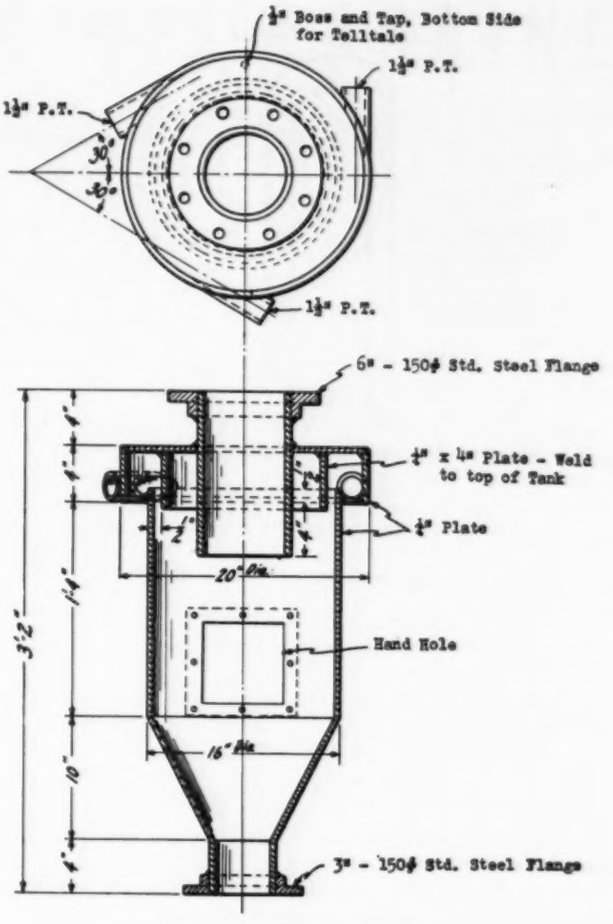


Fig. 8—Cyclonic ash mixer

Because of our experience with the first valve of this type, mufflers were purchased at a high cost. One of these mufflers exploded due to the use of improper material, and we therefore designed our own, many of which have been made and installed in the past five years. This muffler, which is shown in Fig. 9, can be made by any pipe fabricator. It must be kept in mind that when a muffler is used, the relief pipe must be fastened securely to the valve. Shock pressures as high as 500 lb per sq in. at the valve outlet have been reported with 900-lb popping pressure. The regular safety valves required by the Boiler Code have an open end discharge pipe, and this results in a low pressure at the valve outlet. A closed connection at the valve outlet is desirable in order to prevent back blow into the room, but no expansion forces are allowed on the valve because this may cause leakage. This problem has been solved by using high-pressure flexible metal tubing between the valve and the discharge pipe.

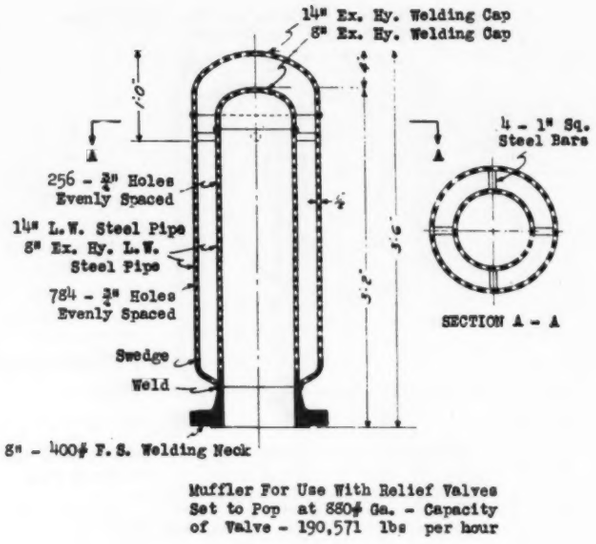

14" Ex. Hy. Welding Cap
8" Ex. Hy. Welding Cap
1'-0"
A
256 - 3/4" Holes Evenly Spaced
14" L.W. Steel Pipe
8" Ex. Hy. L.W. Steel Pipe
784 - 3/4" Holes Evenly Spaced
Swedge
Weld
8" - 400# F.S. Welding Neck
4 - 1" Sq. Steel Bars
A
SECTION A - A
Muffler For Use With Relief Valves Set to Pop at 880# Ga. - Capacity of Valve - 190,571 lbs per hour

Fig. 9—Safety-valve muffler

Circulating-Water Piping

There is nothing unusual about the circulating-water piping, except the way that the air is eliminated at the top of the system. This is accomplished by having the vent, at the highest point on the condenser or piping, carried down about 20 ft and connected back into the circulating water discharge with an elbow on the inside turned downward (see vent line on diagram Fig. 2). Once flow has been started, the falling water will keep the air removed through this vent line which is 2 in.

A 6-in. backwash line is connected between the inlet water box on the condenser and the discharge pipe. This connection is used to drain the circulating water from the condenser back through the inlet water box and thereby wash leaves and trash from the inlet tube sheet without opening the condenser each time. While this is being done, the condenser is operated on one side. In plants where warm water is required at the intake screens in the winter, a recirculating water line is run from the condensers to the intake house and a maximum of ten per cent of the cooling water is sent back to the screen house to prevent ice accumulation on the trash racks and screens. A valve located in the condenser discharge pipe must be partly closed when the recirculating water valve is opened.

Oil Piping

All oil piping is made up with litharge and glycerine as pipe thread compound. Special pipe compound and also back-welded joints have failed to prevent the oil from sweating through the joint in time. On flanged connections, Vellumoid gaskets have given good results.

Drinking Water

Steam power plant sites do not always have drinking water available, and at times, this water must be transported some distance. It has been found that aerated condensed steam makes a rather good quality of drinking water. In one plant the condensate drips from the evaporator steam conductivity cell are being used for this purpose. The conductivity-cell condenser or cooler is located in the turbine room basement and the drips are raised by the steam pressure to a tank at the top of the plant. The drips are allowed to fall through the air in the tank, and are then fed by gravity through electric water coolers. One point that must be remembered is that the pressure of the condensate in the condenser must be higher than the pressure of the cooling water, so that any leakage that might take place will be condensate into the cooling water.

Drips and Drains

A high value is placed upon all usable condensate in a steam plant and for that reason every drop is saved. All condensate, hot or cold, is returned to the flash tank. This tank has an automatic drainer that allows the condensate to flow back to the low-pressure heater while the turbine is in operation. If no units are running, into which this condensate can be returned, the flash tank is allowed to overflow into a drip receiver pump and the condensate is pumped to the clear well.

Fire Protection

Ample fire hose connections should be provided to fight a fire in any part of the plant. Fog or adjustable spray nozzles are provided at all locations where an oil or

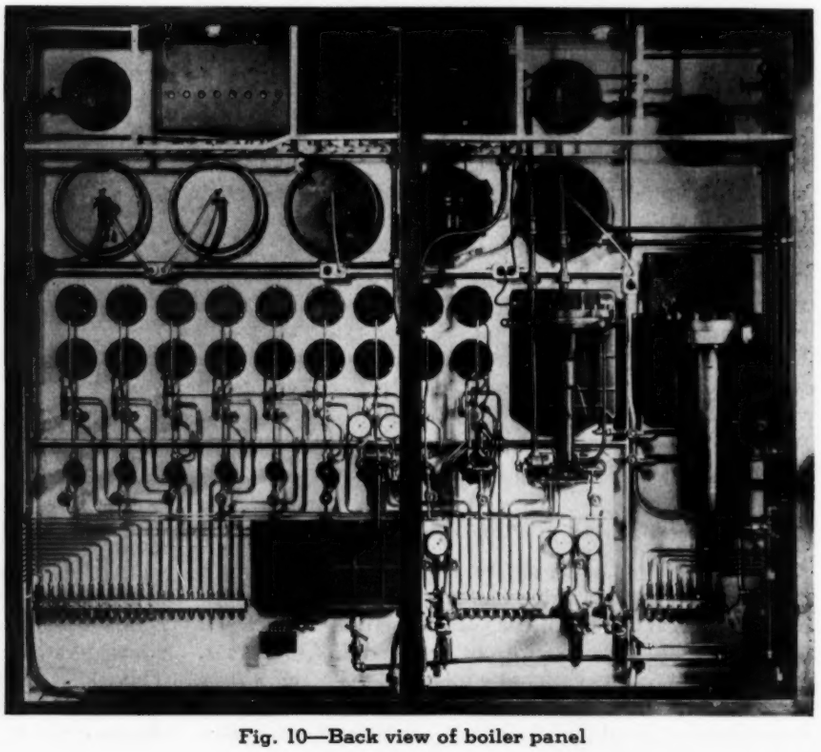


Fig. 10—Back view of boiler panel

pulverized fuel fire may be expected to occur. Fixed Mulsifyre systems are installed at points where a transformer fire might jeopardize adjacent equipment or structures. In order that ample pressure may be assured for the operation of fog and spray nozzles at the top elevations in the plant, the fire protection system is connected to both the house service water and the high-pressure ash-sluicing water through check valves (see upper right-hand corner of Fig. 2). Solid stream nozzles are provided for storerooms, coal handling and outdoor stations.

Low-Pressure Piping

For the general run of low-pressure piping, shop-welded sections are used. These are designed and fabricated in as large pieces as can be handled in shipping and erection. Some welding is done in the field, but most of the field joints are bolted. There are several reasons for this procedure. First, with accurate engineering and fabrication, the piping can be erected with a minimum amount of field work. Second, field changes cannot be made readily by the erector. Third, the engineer is sure that provision has been made for expansion without watching each piece erected. Fourth, the drawings once made require very little or no changing to incorporate field alterations.

Steel screwed flanges are used in all cases, except where the flexibility of a Van Stone flange is desired. Steel flanges are used in preference to cast iron to avoid leaks caused by cracked flanges. Seldom is a thread leak found in a shop-fabricated joint, but if a leak should occur, it can be welded with a steel flange. Unreinforced welded branch connections are used throughout because of cost. There is no branch connection that can be made at a lower cost, except the use of cast-iron screwed tees, and these are regarded as inferior for power-plant piping. Pipe bends are used for all turns where room permits because they give the greatest flexibility at the lowest cost.

Tapped openings are provided in the shop for thermometers, pressure gages, drips, etc. All hangers are furnished by the pipe fabricator and delivered to the field with the piping so that all material can be erected in their permanent hangers.

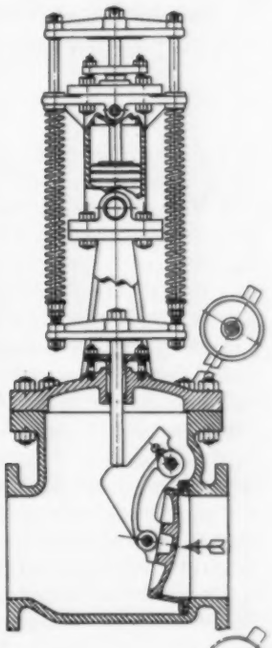
Instrument Piping

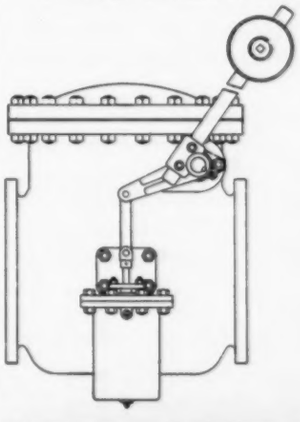
In order that instruments and combustion-control equipment may be selected from various manufacturers, rather than from one company, we design all of our instrument and control panels and piping. The panel structure is purchased from a steel specialty fabricator and is built in accordance with our specifications. It is then sent to another company where all the panel instruments are mounted, piped up and wired after the steel plate has been sanded and lacquered. The panels are then delivered to the field as a unit. Fig. 10 shows the back view of a boiler panel ready for crating and shipment. It is our thought that each instrument manufacturer has some equipment that is superior to his competitor's equipment for similar services. It is for that reason, and in order to get competitive bids on all instruments, that we design our own units. The combustion-control equipment is sometimes a mixture of several makes.

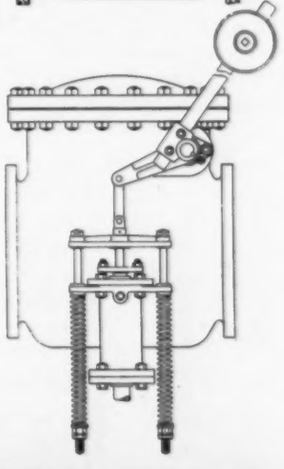
DAVIS TURBINE NON-RETURN VALVES

THE Davis line of Turbine Non-Return Valves includes a wide choice of tested designs developed through many years of experience in working with the nation's foremost power plant designers and engineers. These designs include both poppet type valves and the counterbalanced swing check type of valve shown here. Auxiliary features include spring loaded oil cylinders and trip levers to insure quick, positive closing in case of emergency.

All Davis Turbine Non-Return Valves are designed to provide maximum safety, sensitive action, and unrestricted flow. Standard sizes from 4″ to 24″. For any pressure. For information, recommendations, and literature, write DAVIS REGULATOR CO., 2510 S. Washtenaw Ave., Chicago, Ill.







Davis No. 134 Counterbalanced swing check type non-return valve.

RIGHT—No. 135 with oil control cylinder mounted above valve.

LOWER LEFT—No. 134 with oil dash pot.

LOWER RIGHT—No. 137 with oil control cylinder on side.

DAVIS VALVES

DAVIS REGULATOR CO.

Combustion Calculations By Graphical Methods— WOOD AND BAGASSE

By A. L. NICOLAI
Combustion Engineering Co., Inc.

This is the concluding article of the series which has appeared in alternate issues since August 1941 and covered the whole range in commercial fuels with charts for conveniently arriving at their combustion calculations.

WOOD is made up of carbohydrates, moisture and ash. On a dry basis, it consists of about 55 per cent fiber or cellulose, 27 per cent lignin, 17 per cent "extractives" and 1 per cent ash. Cellulose, $(C_6H_{10}O_5)_y$, is a carbohydrate which derives its name from the fact that it forms the cellular, fibrous framework in wood that encloses other carbohydrates, such as starches and sugars, having the same chemical formula as cellulose but different properties. As plants grow, some of the cellulose tissue hardens and is converted into lignin, a complex substance related to the carbohydrates, but containing less oxygen. Extractives are substances within the wood fiber which can be dissolved out with water, ether, benzene or other inert solvents. Among the wood extractives may be found sugars, tannin, vegetable acids, essential oils, resins and pigments.

The ultimate analyses of several different woods are listed in Table 1, where it is seen that carbon, C, hydrogen, H_2, and oxygen, O_2, are the main constituents, accompanied by small percentages of ash and negligible quantities of sulphur, S, and nitrogen, N_2. When compared with other fuels, the chief characteristic of a wood analysis is its high oxygen content which influences both the heating value and the air required for combustion.

Of the total volume of timber cut in the U. S., it is estimated that only 41.7 per cent is converted into lumber, while 28.9 per cent is logging waste and 29.4 per cent is sawmill waste.[1]

When used to generate steam, wood is burned mostly as refuse from milling or extraction process operations. In this form it consists of sawdust, shavings, chips, wood "flour," or bark and sticks. A typical sample of wood refuse might contain 84 per cent bark, 9 per cent cull wood and 7 per cent sawdust. Again, the sawdust refuse from an alcohol manufacturing plant may be used as fuel. The sawdust from sawmills is charged into a digester, mixed with dilute sulphuric acid and heated with steam to about 335 F. After cooking for an hour, the mixture is taken to "diffusion batteries" where the soluble constituents which are later converted into alcohol are extracted with hot water. The solid refuse is then pressed to reduce the water content to about 55 per cent and sent to the steam plant as fuel.

Where a more effective extraction is desired, the wood is first passed through a "hogger," which cuts, shreds or hammers it down to a small uniform size. In this condition it is used to manufacture tannin. The hogged chips are placed in tanks and boiled with water, and the resulting liquor is withdrawn and refined, whereas the

[1] "Chemical Utilization of Wood," by H. K. Benson.

TABLE 1—TYPICAL ANALYSES OF WOOD, DRY

	Per Cent by Weight						Heating Value, Btu per Lb		Atmos. Air at Zero Excess Air,	CO_2 at Zero Excess
Softwoods†	Carbon, C	Hydrogen, H_2	Sulphur, S	Oxygen, O_2	Nitrogen, N_2	Ash	High	Low	Lb/10⁶ Btu	Air, %
Cedar, white	48.80	6.37	...	44.46	..	0.37	8400*	7780	709	20.2
Cypress	54.98	6.54	...	38.08	..	0.40	9870*	9234	712	19.5
Fir, Douglas	52.3	6.3	...	40.5	0.1	0.8	9050	8438	719	19.9
Hemlock, western	50.4	5.8	0.1	41.4	0.1	2.2	8620	8056	705	20.4
Pine, pitch	59.00	7.19	...	32.68	..	1.13	11320*	10620	702	18.7
white	52.55	6.08	...	41.25	..	0.12	8900*	8308	722	20.2
yellow	52.60	7.02	...	40.07	..	0.13	9610*	8927	709	19.2
Redwood	53.5	5.9	...	40.3	0.1	0.2	8840	8266	707	20.2
Hardwoods†										
Ash, white	49.73	6.93	...	43.04	..	0.30	8920*	8246	709	19.5
Beech	51.64	6.26	...	41.45	..	0.65	8760*	8151	728	20.1
Birch, white	49.77	6.49	...	43.45	..	0.29	8650*	8019	714	20.0
Elm	50.35	6.57	...	42.34	..	0.74	8810*	8171	717	19.8
Hickory	49.67	6.49	...	43.11	..	0.73	8670*	8039	712	19.9
Maple	50.64	6.02	...	41.74	0.25	1.35	8580	7995	719	20.3
Oak, black	48.78	6.09	...	44.98	..	0.15	8180*	7587	713	20.5
red	49.49	6.62	...	43.74	..	0.15	8690*	8037	711	19.9
white	50.44	6.59	...	42.73	..	0.24	8810*	8169	713	19.8
Poplar	51.64	6.26	...	41.45	..	0.65	8920*	8311	715	20.0

* Calculated from reported high heating value of kiln-dried wood assumed to contain 8 per cent moisture.
† The terms "hard" and "soft" wood, contrary to popular conception, have no reference to the actual hardness of the wood. According to the Wood Handbook, prepared by the Forest Products Laboratory of the U. S. Department of Agriculture, hardwoods belong to the botanical group of trees that are broad-leaved whereas softwoods belong to the group that have needle or scalelike leaves, such as evergreens; cypress, larch and tamarack are exceptions.

TABLE 2—TYPICAL ANALYSES OF BAGASSE, DRY

	Per Cent by Weight					Heating Value, Btu per Lb.		Atmos. Air at Zero Excess Air,	CO_2 at Zero
	Carbon, C	Hydrogen, H_2	Oxygen, O_2	Nitrogen, N_2	Ash	High	Low	Lb/10^6 Btu	Excess Air, %
Cuba	43.15	6.00	47.95	..	2.90	7985	7402	625	21.0
Hawaii	46.20	6.40	45.90	..	1.50	8160	7538	687	20.3
Java	46.03	6.56	45.55	0.18	1.68	8681	8043	651	20.1
Mexico	47.30	6.08	35.30	..	11.32	9140	8548	667	19.4
Peru	49.00	5.89	43.36	..	1.75	8380	7807	699	20.5
Porto Rico	44.21	6.31	47.72	0.41	1.35	8386	7773	625	20.5

wood residue is sent to a furnace after some of the water has been squeezed out of it by presses. Wood waste from the extraction of turpentine, pine oil and rosin may be similarly burned to produce steam.

Less often, fuel wood is in the form of slabs, blocks, or logs and occasionally as cordwood, the latter consisting of logs 4 to 4.5 ft long and 3 to 5 in. in diameter.

Bagasse

Bagasse is a waste fuel that is produced when sugar is extracted from cane. The cane stalks grow in the field from 10 to 12 ft high. In Latin America it is customary to cut the stalks again into smaller pieces, 2 to 3 ft long, before sending them through shredding machines or rotary knives. The shredding, or cutting operation, is called "disintegration" or "defibration," and serves to open up the hard rind and thereby facilitate the squeezing out of the juice in the cane.

As in the case of wood, sugar cane consists of cellulose fiber which makes up the tissue enclosing such sugars as sucrose ($C_{12}H_{22}O_{11}$) and glucose ($C_6H_{12}O_6$). Water and small quantities of mineral ash are also present. On a moisture and ash free basis, the cane contains from 10 to 17 per cent cellulose fiber and from 83 to 90 per cent sugar.

In order to separate the juice from the fiber, the disintegrated cane is crushed between rollers. After this primary pressing, the issuing fiber, or "bagasse," is sent through more roller mills for further extraction, as illustrated in Fig. 1. At the same time that the bagasse undergoes additional squeezing it is sprayed, or "imbibed," with plain water or diluted juice to help dissolve more of the sugar. When hot water, generally taken from the boiler feed line, is used to soak the bagasse, the operation is known as "maceration." On leaving the last mill, a typical bagasse might have 40.0 per cent fiber, 2.5 per cent sugar, 55.0 per cent moisture and 2.5 per cent ash. The relatively high ash content in many samples of bagasse is due to trash and dirt picked up in harvesting the cane.

Table 2 shows six typical ultimate analyses of bagasse from different countries. The carbon content is slightly lower and the oxygen a little higher than in wood, possibly due to the extraction of sugar.

The size of bagasse pieces is dependent on the machinery employed to disintegrate the cane. A simple crusher will produce coarser bagasse than is obtained by adding a shredder ahead of the crusher. Aside from the special case where grindstones defibrate the cane, the finest size is obtained with rotating knives replacing both shredder and crusher.

Moisture.—Moisture is the most variable single item in the composition of both wood and bagasse, its value ranging from 6 per cent in kiln-dried woods to over 60 per cent in green wood or bagasse and up to 80 per cent in bark. It is of importance in combustion calculations because it directly influences the heating value of the fuel burned by increasing the proportion of inert matter present. Furthermore, it requires some of the heat released by the dry substance to evaporate and superheat it.

An accurate determination of the moisture content in wood or bagasse is, therefore, necessary. To obtain it, a weighed sample is placed in a steam or electric oven and heated to 212 F until no further loss of weight occurs. The difference between the original weight and that of the dried sample divided by the original weight is the moisture fraction "as received." In the lumber industry it is customary to speak of moisture in wood on the "oven-dry" basis, whereby the loss of weight in the sample tested is divided by the oven-dried weight rather than the original weight. The per cent moisture "oven-dry" must then be converted to the "as received" basis before using it in combustion calculations.

The oven-drying method of determining the moisture content is not accurate with woods such as southern yellow pine, which contain oils that are easily volatilized, because these oils will distill with the moisture. Recourse is then had to the more elaborate distillation method, wherein the water and the oil are measured separately.

Other less reliable, but quicker, ways of judging the moisture in wood consist in measuring its electrical resistance or using a wood hygrometer.

As a rule, "kiln-dried" woods contain from 6 to 10 per cent moisture, although softwoods will show a much higher percentage unless properly handled in the kiln. "Air-dried" woods have had enough moisture evaporated to be in equilibrium with the surrounding atmosphere. The actual percentage present is dependent on both the

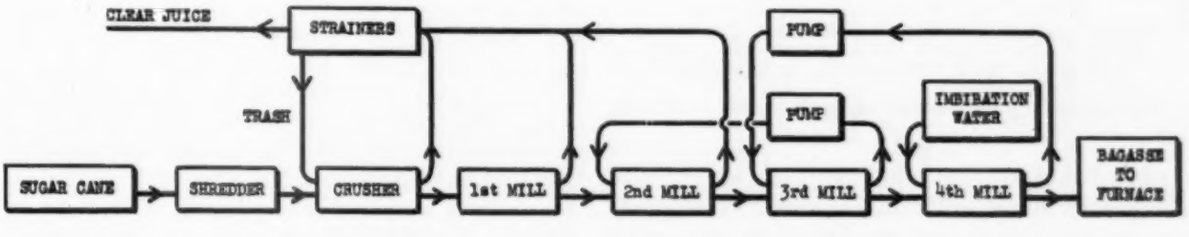


Fig. 1—Diagram showing how bagasse is obtained as a by-product in the extraction of sugar from cane

temperature and relative humidity of the surrounding atmosphere. Fig. 2 shows how the moisture in wood varies with different relative humidities at 70 F. In arid climates it may be as low as 5 per cent, whereas in humid regions it may go up to 20 per cent or more. Green wood, wood waste and bagasse contain from 40 to over 60 per cent moisture.

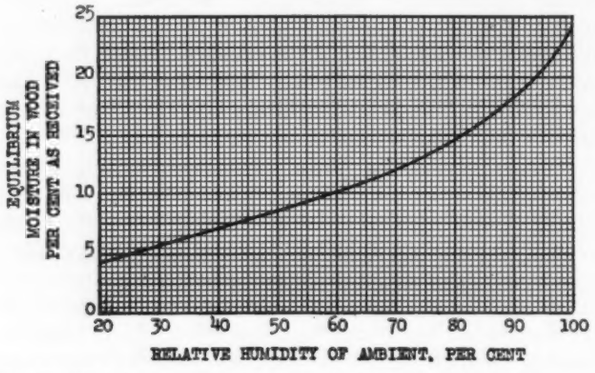


Fig. 2—Moisture content of wood at 70 F ambient temperature

Heating Value.—The high heating value of wood or bagasse is determined by a bomb calorimeter, as in the case of other solid fuels. From the close similarity of the ultimate analyses of different woods, it might be reasonable to assume that equal weights of dry wood will release the same amount of heat, regardless of species. Actually, as Table 1 indicates, this is not the case, the heating value of wood depending to some extent on the physical structure and form of the wood tissue, and still more on the presence of resins, gums, tannins, essential oils, or pigments. Resin alone, for instance, may increase the heating value of the same wood as much as 15 per cent. Table 1 shows that the Btu per pound of dry softwoods is a little higher, on the average, than that of hardwoods, due perhaps to the fact that most softwoods are conifers containing resin and oils.

As mentioned before, however, the chief factor affecting the heating value of the wood or bagasse as fired into a furnace is its moisture content. In the case of wood refuse, the heating value may also be influenced by the amount of trash and dirt gathered in processing the wood. In harvesting sugar cane, a certain amount of trash, leaves, cane tops and grass may be included which would

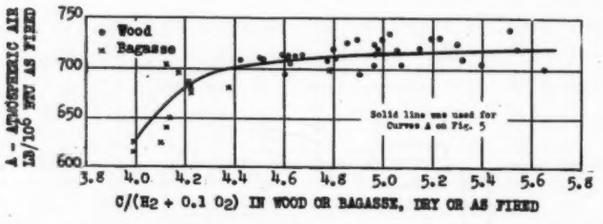

A - ATMOSPHERIC AIR LB/10⁶ BTU AS FIRED
600
650
700
750
• Wood
× Bagasse
Solid line was used for Curves A on Fig. 5
3.8 4.0 4.2 4.4 4.6 4.8 5.0 5.2 5.4 5.6 5.8
C/(H2 + 0.1 O2) IN WOOD OR BAGASSE, DRY OR AS FIRED

Fig. 3—Variation of theoretical air with $C/(H_2 + 0.1\ O_2)$

result in a lower heating value for the bagasse. As a rule, larger quantities of trash and dirt are picked up when the cane is harvested and loaded by mechanical means than when it is handled by hand.

Owing to the complex substances composing them, it is not possible to make use of Dulong's formula to predict the heating value of either wood or bagasse. Dulong's formula appears to give too low values of available hydrogen in the factor $\left(H_2 - \frac{O_2}{8}\right)$ and as a result the heating values calculated with it are invariably low.

In sugar-mill practice, bagasse analyses are frequently reported in terms of its fiber, sucrose, glucose, moisture and ash content. If these are given, the high heating value (*HHV*) of bagasse in Btu per pound may be computed from

$$HHV = 8550(F) + 7119(S) + 6750(G) - 972(M) \qquad (23)$$

where

F = fiber, lb per lb of bagasse
S = sucrose, lb per lb of bagasse
G = glucose, lb per lb of bagasse
M = moisture, lb per lb of bagasse

Knowing the high heating value of either wood or bagasse, the low heating value (*LHV*) in Btu per pound at constant pressure may be obtained from

$$LHV = HHV - 9720\ H_2 - 1110\ H_2O \qquad (21)$$

H_2 and H_2O in this equation are the weight fractions of

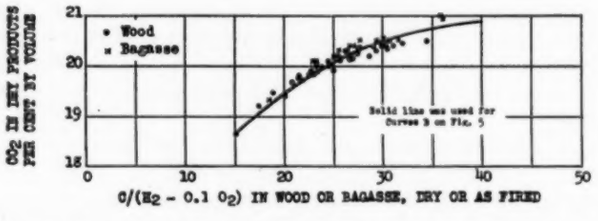

CO2 IN DRY PRODUCTS PER CENT BY VOLUME
18
19
20
21
• Wood
× Bagasse
Solid line was used for Curves B on Fig. 5
0 10 20 30 40 50
C/(H2 - 0.1 O2) IN WOOD OR BAGASSE, DRY OR AS FIRED

Fig. 4—Variation of theoretical CO_2 with $C/(H_2 - 0.1\ O_2)$

hydrogen and moisture, respectively, taken from the ultimate analysis.

Fuels in Products, F.—The combustible loss in burning wood or bagasse in a properly designed furnace is generally assumed to be zero. Therefore, if the high heating value and the ash content of these fuels are known, that portion, F, of the fuel that reappears in the products of combustion may be taken directly from Fig. 1 of the August 1941 article of this series in COMBUSTION.

Atmospheric Air, A.—Curves A of Fig. 5 offer a convenient way of obtaining the "atmospheric air," A, in pounds per million Btu fired, for any excess air value up to 100 per cent after calculating the ratio $\left[\frac{C}{H_2 + 0.1\ O_2}\right]$ from the ultimate analysis of wood or bagasse. These lines are based on the correlation, between this ratio and the theoretical air required, shown by Fig. 3. It will be noted that the points on Fig. 3 are much more scattered than they were with similar correlations for coal and coke. The principal reason for such relatively large deviations from the solid line of Fig. 3 is probably the fact that most of the data published is old, and of doubtful accuracy in view of later progress in the technique of testing. Henry Kreisinger points out that there is evidence that the carbon and the hydrogen in these old analyses are low, whereas the oxygen is high. The weight

of air calculated with such analyses is, therefore, low. In his paper on the "Combustion of Wood-Waste Fuels"[2] it may be noted that separate testing laboratories report consistently different heating values for the woods analyzed. The different sources from which analyses and heating values of bagasse were obtained may then explain, at least partly, the varying theoretical air plotted on Fig. 3.

Moisture in Fuel, W_f.—The total moisture in the products of combustion of either wood or bagasse has been denoted by the symbol W_f, pounds per million Btu. It is the sum of W_e, the moisture originally in the fuel and W_h, the water formed from the combustion of hydrogen.

When the ultimate analysis of wood or bagasse as fired is known, as well as the high heating value, W_e may be read directly from Curves D and W_h from Curves C of Fig. 5.

Per Cent CO_2 in Products.—The per cent CO_2 by volume in the dry products of combustion may be determined from Curves B of Fig. 5 for any excess air from zero to 100 per cent of theoretical requirements. Curves B are based on the solid line of Fig. 4, which shows the change in the ultimate CO_2 with the ratio $\left[\frac{C}{H_2 - 0.1\,O_2}\right]$. The correlation of Fig. 4 shows that no value deviates from the solid line by more than ±0.2 per cent CO_2. This is the accuracy that may be expected in reading Curves B.

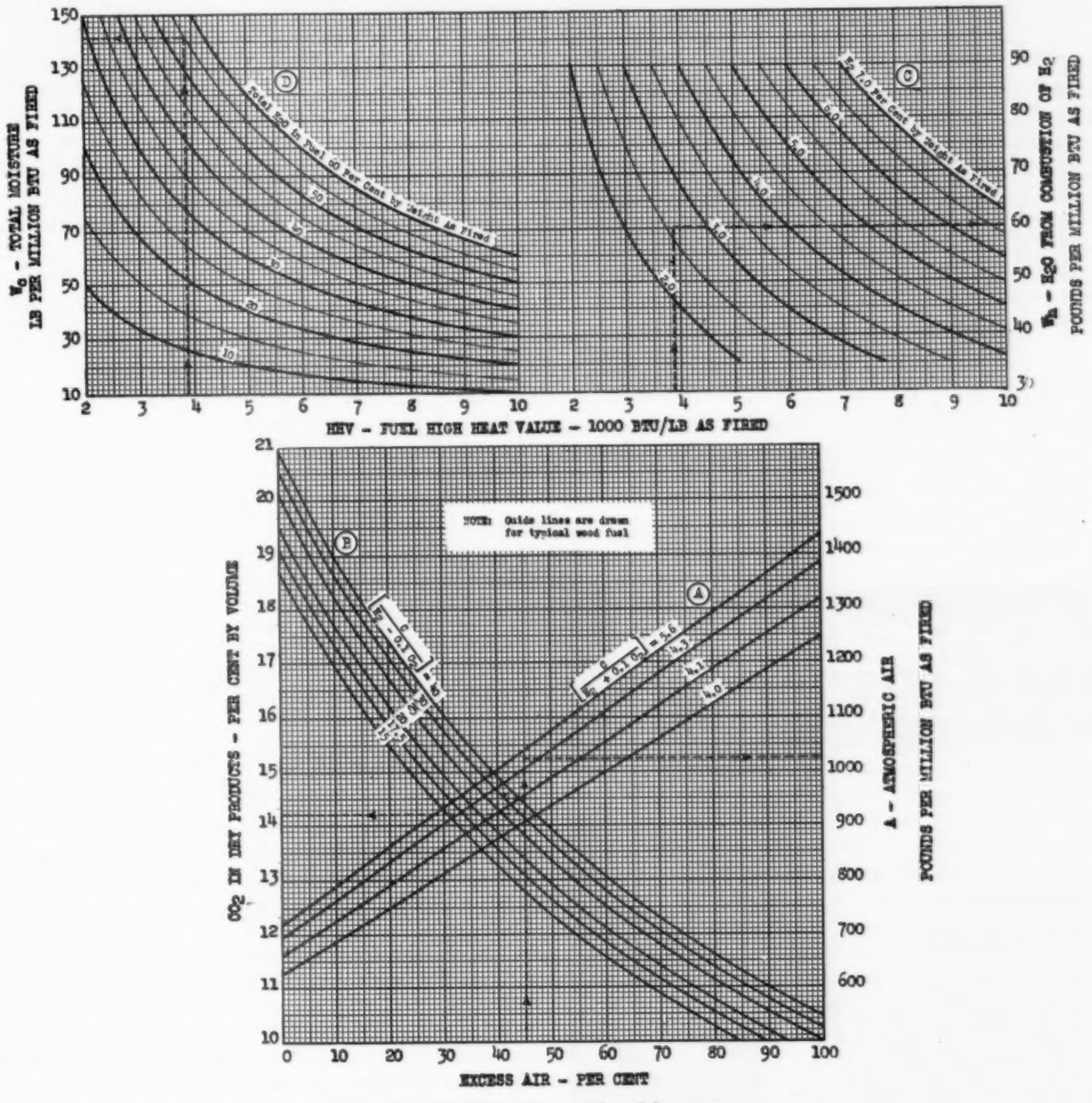

W_e - TOTAL MOISTURE LB PER MILLION BTU AS FIRED
W_h - H_2O FROM COMBUSTION OF H_2 POUNDS PER MILLION BTU AS FIRED
HHV - FUEL HIGH HEAT VALUE - 1000 BTU/LB AS FIRED
Total H_2O in fuel 60 Per Cent by weight as fired
Per Cent by weight as fired
NOTE: Guide lines are drawn for typical wood fuel
CO_2 IN DRY PRODUCTS - PER CENT BY VOLUME
A - ATMOSPHERIC AIR POUNDS PER MILLION BTU AS FIRED
EXCESS AIR - PER CENT

Fig. 5—Chart for wood and bagasse

Example

Assume that saw-mill refuse from Western hemlock, containing 55 per cent moisture as fired and having the ultimate analysis shown in Table 1, is burned with 45 per cent excess air. Then

[2] Presented at the A.S.M.E. Spring Meeting, New Orleans, Feb. 23–25, 1939, and printed in *Mechanical Engineering* of February 1940.

1. *Fuel F.* Convert both the ash and the high heating value of Table 1 from the dry to the "as-fired" condition, or, ash = 2.2 $\left(\frac{100-55}{100}\right)$ = 1.0 per cent as fired and $HHV = 8620\left(\frac{100-55}{100}\right)$ = 3880 Btu per lb as fired. With these values for ash and *HHV*, read from Fig. 1 of the August 1941 article in COMBUSTION, F = 255 lb per million Btu.

2. *Atmospheric Air, A.* Calculate the ratio $\left[\frac{C}{H_2 + 0.1\,O_2}\right]$ = $\left[\frac{50.4}{5.8 + 0.1 \times 41.4}\right]$ = 5.07 and with this ratio read from Curves A, Fig. 5, for 45 per cent excess air, A = 1025 lb per million Btu.

3. *Unburned Combustible Factor, C.* The usual assumption when burning wood in steam boiler furnaces is that the combustible loss is zero, consequently C in equations (3) and (4)[3] may be taken as 1.

4. *Total Products, P,* From equation (4),[3] $P = F + CA$ = $255 + 1 \times 1025$ = 1280 lb per million Btu.

5. *Moisture in Air, W_a.* From equation (5),[3] $W_a = 0.013A$ = 0.013×1025 = 13 lb per million Btu.

6. *Moisture from Fuel, W_f.* The total moisture in the products of combustion of wood, W_f, is the sum of W_a, the moisture in the wood as fired, and W_h, the water formed by its combustion. Since the wood contains 55 per cent moisture as fired and its high heating value as determined for F is 3880 Btu per lb, from Curves D of Fig. 5, W_c = 142 lb per million Btu. Next, convert the per cent hydrogen in Table 1 from the dry to the as-fired basis, or, H_2 = 5.8 $\left(\frac{100-55}{100}\right)$ = 2.6 per cent as fired, and with a high heating value of 3880 Btu read from Curves C, Fig. 5, W_h = 60 lb per million Btu. Then

$$W_f = W_c + W_h = 142 + 60 = 202 \text{ lb per million Btu}$$

7. *Dry Gas, P_d.* From equation (7),[3] $P_d = P - (W_a + W_f)$ = $1280 - (13 + 202)$ = 1065 lb per million Btu.

8. *Per Cent CO_2 in Products.* Compute the ratio $\left[\frac{C}{H_2 - 0.1\,O_2}\right]$ = $\left[\frac{50.4}{5.8 - 0.1 \times 41.4}\right]$ = 30.4 and for 45 per cent excess air read on Curves B, Fig. 5, CO_2 = 14.2 per cent.

[3] See COMBUSTION, August 1941.

New Style PUMPS
for the New Ships
On many of the ships recently built and now under construction, the methods of handling fuel and lubricating oil have been vastly improved by adoption of the
De Laval-IMO Oil Pump
Its exceptional compactness and its ability to operate directly connected at motor and turbine speeds save space and weight, and greatly simplify the power plant layout. There are only three moving parts; no valves, no gears, no separate bearings, no reciprocating parts. The pump interior is readily accessible.
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To handle 175 g.p.m. of 200 to 500 SSU lube oil against 50 lb. gage from 15 in. Hg. suction at 1750 r.p.m.
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Advances in Mine Prices Recommended

Recommendations for the first overall revision of minimum mine prices for bituminous coal, proposing a weighted country-wide average increase of 15 cents a ton, have been filed with the Bituminous Coal Division of the Department of the Interior, by the examiner designated to make a survey.

This is in line with the provisions of the Bituminous Coal Act of 1937 which required that minimum prices be set at levels to give the coal producers an average realization, in each price area, that will approximate the weighted average cost for that area. It is now nearly two years since minimum prices were first established. The recommendations grouped into certain regions are as follows:

For coal shipped into the Eastern Seaboard as far west as Michigan less the Upper Peninsula, south along the Indiana and Ohio State lines, through the center of Kentucky and Tennessee and south along Alabama and Georgia State lines, and Eastern Canada: 20 cents increase in the present minimum price schedules of the various districts in each minimum area.

Greater Chicago and its switching limits; Greater Louisville and Indiana except west, central and southwest portion: 10 cents increase.

Wisconsin, Upper Peninsula of Michigan, all of North and South Dakota except the small market area in southwest South Dakota and Montana: 15 cents increase.

West and south central Indiana, all Illinois except Greater Chicago, Iowa, Missouri, west portions of Kentucky, and Tennessee, Mississippi, Arkansas and Louisiana: 5 cents.

Alabama, few isolated market areas in west central Georgia, and northwest Florida: 30 cents.

Wyoming, Utah, Idaho, Oregon, Nevada, California and Black Hills region of South Dakota: 5 cents.

Nebraska, Kansas, Oklahoma and Texas except west central portion: 10 cents.

Colorado, Arizona, New Mexico and west central Texas: 30 cents.

Washington, Alaska and Western Canada: 25 cents.

None of these prices apply to railroad coal which is covered by a separate schedule. Moreover, they are subject to revision by the Acting Director of the Bituminous Coal Division following the filing of exceptions.

New Process to Make Petroleum From Coal

New research in the production of liquid motor fuels and lubricants from coal by a process not hitherto investigated in the United States has been authorized in a recent appropriation by Congress to the Bureau of Mines.

The Fischer-Tropsch method, developed and now industrially operating in Germany, has a number of advantages over the modified Bergius hydrogenation method which has been investigated by the Bureau for a number of years. Both methods start with coal, but the Fischer-Tropsch process gives a number of the separated fuel and lubricant products directly, while the output of the Bergius process is a single liquefied coal which is further treated much like crude oil in a regular refining process.

A further claimed advantage of the new method is that much smaller plants are economically possible, about 30,000 tons a day against 150,000 tons a day for the Bergius process. This enables a wider and safer distribution of plants. Also, the Fischer-Tropsch process requires less precision machinery. Both processes produce about one ton (between 250 and 300 gallons) of liquid products from four to five tons of coal.

Latitude in Coal Selection Through Plant Modernization*

By THEODORE MAYNZ

American Viscose Corporation

This relates the experience of one plant in burning Fairmount District coal. With the original boilers and stokers it was impossible to attain the expected steam output. These were later rebuilt, replacing the refractory setting with water cooling and firing with underfeed stokers of both the water-cooled and the air-cooled types. With these changes satisfactory performance has been attained. Two other units in the plant which burn this coal in pulverized form regularly carry the base load at full output without difficulty.

SIMILAR to many industrial power plants, our Parkersburg plant, built in 1926, followed the general lines of some of our previous plants in the type of equipment that was installed. However, it was soon apparent that this equipment, though moderately successful in our other plants, was not able to burn the local, Fairmount District coals, so that it became necessary to burn fuel from another district at an increase in price both for the coal and its freight charges. Furthermore, though the boilers and stokers were guaranteed to produce 90,000 lb of steam per hour, this output was never reached, and even with low-ash, high Btu fuel, approximately 65,000 lb was the limit for practical operation. The all-refractory setting, the absence of a boiler slag screen, the inclined front arch, all tended toward extremely high furnace temperatures and consequent plugging of the gas passages. Fire conditions, even at low ratings, were bad, the stoker quickly "freezing" with molten ash. The addition of air preheaters designed to give 395 F air did not help the stoker and furnace to "digest" its fuel, even though the air temperature never exceeded 275 F.

The boilers each had 10,000 sq ft of heating surface, the stokers 200 sq ft of projected area, including the clinker grinder, and the furnaces approximately 30,000 cu ft volume. Based on an hourly output of 90,000 lb of steam, and 13,300 Btu coal, the fuel-burning rate figured about 50 lb per sq ft and the heat release about 43,000 Btu per cu ft. It can be readily seen that the performance guarantee under these conditions was, to say the least, extremely optimistic.

Pulverized-Coal-Fired Units

When in 1930 more steam was required, a new steam generator using the bin system of pulverized coal was installed. This unit was of fairly good design, the boiler having 10,160 sq ft of heating surface, with a furnace volume of 7500 cu ft, and a total of 1610 sq ft of water walls, including the bottom slag screen. The front wall was refractory. Designed to produce 120,000 lb of steam per hour, it included a small economizer ahead of the plate type air preheater. Although this rating could be reached before the addition of a dust collector reduced the capacity of the induced-draft fan, trouble was experienced with erosion of the front wall and blocking of the bottom slag screen at the rear end. This necessitated removal of the unit from service for cleaning and front wall repairs about once every six weeks. Fairmount District $^3/_4$-in. slack is the only fuel ever used with this unit.

About two years later a similar unit was installed, but the economizer was eliminated, the water-wall surface was increased to 1730 sq ft, and the furnace was equipped with three of a newer type of horizontal turbulent burners. The performance of this unit has been excellent, so that in 1940 the burners of the 1930 unit were changed from two of the original type to three of the improved type. Subsequent performance with this arrangement has more than justified the cost in sustained capacity and decreased outage.

These two boilers, Nos. 5 and 6, are under hand control with variable-speed slip ring motors driving the induced- and forced-draft fans, and since they burn the lower cost coal, they are base loaded at 100,000 to 110,000 lb per hr output. The stoker-fired boilers, Nos. 1 to 4, take the swings of a quite constant load. They are also under hand control of the slip ring induced-draft fan motors, turbine-driven forced-draft fans, and four-speed stoker-drive motors.

Studies made in 1940 indicated that changing the stoker-fired boilers so that they could burn the Fairmount coals warranted a considerable expenditure for rehabilitation, and consideration was given as to whether it would be advisable to convert to pulverized coal. However, among the factors that weighed against the use of pulverized coal was the necessity of increasing the air preheaters, the addition of dust collectors, and the consequent expense of larger induced- and forced-draft fans and drivers. Furthermore, adequate space for a workable installation of this kind was not available. Also, an entire pulverized-coal boiler plant would have required an interconnection with the public utility for standby power to "crank" the station in case of a complete electric shutdown.

With pulverized coal firing discarded, the next step was to investigate the various types of stokers suitable for burning Fairmount coal. The inherent difficulty of installing an adequate size stoker of the traveling-grate type under the existing boilers and building steel, furthered the decision again the use underfeed stokers.

* From a paper before the Fuel Engineering Conference at Morgantown, W. Va., July 24, 1940.

Selection of Stokers

After a preliminary survey which eliminated all but two makes of underfeed stokers, one water-cooled and the other air-cooled, several carloads of our coal were shipped to two plants having such stokers, and the coal was burned under high rating condition. No difficulty was experienced in burning this fuel at about 45 lb per sq ft of projected grate area per hour, the limit of rating in both cases being the available draft. It was possible to examine both stokers immediately after the tests. There was no doubt that the water-cooled stoker would handle this coal with a minimum of maintenance, and that the air-cooled machine would burn it satisfactorily without preheated air. But with preheated air, it seemed advisable to water cool the tuyere rows to insure a minimum of outage and maintenance.

For the water-cooled stoker we purchased the largest machine that could be crowded into the furnace. This was an 8-retort, 42-tuyere continuous ash discharge, link-grate type having a projected area of 234 sq ft. Due to design problems, the first stoker was accepted without the water cooling, with the understanding that it would be converted later to a water-cooled machine, after the probable "bugs" of the first water-cooling equipment had been eliminated. It is unfortunate that delays have set back our construction program, so that this water-cooled stoker is not yet in operation; hence its performance cannot be reported.

Changes in Stoker-Fired Boilers

Extensive changes were made in the boiler. It was equipped with a water-cooled rear wall, with bolted-on cast-iron blocks at the lower end, the tubes being $3^1/_4$ in. on $4^1/_4$-in. spacing. The side walls are cooled by seven rows of inclined tubes, the lower five being protected by cast-on iron blocks, and the front wall and inclined arch are cooled by 4-in. tubes which also form the lower two rows of the slag screen. An additional slag screen is obtained by removal of the original bottom two rows of boiler tubes. The reinserted tubes have double spacing, and drop down to the lowest tube holes of the front header. The downcomers feeding all of the new headers consist of eighteen 4-in. tubes. Six feed the front-wall header, eight feed the rear-wall header, and two feed each of the rear side-wall headers. Each front side-wall header has two steam release tubes, which form part of the slag screen.

The entire upper side walls were supported by temporary steel work, and new side walls were built from the floor steel to about the upper tube deck line. These lower walls are $22^1/_2$ in. thick, to conform with the original walls and they consist of 9 in. of plastic, 3 in. of Super X block, a 6-in. air space and $4^1/_2$ in. of red brick on the outside. The supporting steel for the plastic panels is in the air space, which is ventilated. This was an extremely difficult job and, in spite of its intricacies, was well accomplished. Its cost was no greater than a solid refractory wall. Four additional hand-lancing doors on each side wall, for slag removal, along the slag screen tubes, were also installed. The front wall behind the tubes is only 9 in. thick, of solid refractory, and has expansion joints. It is braced by a steel channel.

Air-operated automatic control maintains the furnace draft by throttling the steam-driven forced-draft fans, proportions the fuel feed to the gas flow by controlling the steam flow to the turbine gear-box stoker drive, and the boiler output by the inlet damper to the induced-draft fan. A signal device, on the control board, with a red and green light, warns the operator when the damper is almost wide open or almost closed, so that he can then either increase or decrease the fan motor speed, by means of the original manual control of the wound-rotor resistance box placed just in back of the control board.

The operating board has a steam gage, two three-pointer draft gages, one for air and the other for gas pressures, a boiler meter with a superheat recording pen, and a three-pen temperature-recorder for gas and air temperatures. The operating controls and re-sets of the combustion control system are mounted below the meters, while the fuel-air manometers are mounted between the recorders.

The water-cooled stoker is similar to the air-cooled machine, except that each tuyere row has a tube running along the tuyeres, ending in a header under the rear end of the tuyere section. The front ends of these tubes enter a heat exchanger. Water circulates in these tubes and steam is generated at a pressure of 15 lb per sq in. The steam is condensed in the heat exchanger and the pressure is regulated by the amount of cooling water supplied to it. Thus by a continuous enclosed system, there should be no danger of scale formation in the tuyere cooling tubes.

The air-cooled machine has been in operation since February 15, 1942, and to date there have been only two short outages, both due to failure of some old pitted boiler tubes. Examination of the furnace and stoker showed no signs of burning of any stoker parts. The bolted-on cast-iron blocks on the rear wall show some burning, not serious, but probably more than would have occurred with cast-on blocks, such as are used on the side-wall cooling tubes and in several of our other plants. Some erosion, due to intense flame impingement, has occurred on the left side wall, but this is believed to be due to bad coal segregation, as this side habitually carries a thinner fire than the other. A non-segregating coal spreader will probably eliminate this.

Conclusions

This Fairmount District coal does not seem difficult to burn, provided certain precautions are taken in the choice and design of the equipment. Ignition is quick and its grindability fair, so that, if the furnace is correct, no trouble should be experienced when burning it in pulverized form. Sufficient water cooling and slag screen should be provided to cool the ash (dry bottom ash pits) and to prevent blocking of the boiler tube passages. Because of the long flame, setting heights should be generous, especially with cold furnaces. Due to the volatile, low combustion rates can be obtained and therefore it is a flexible fuel for varying loads.

On account of the action of the ash on the iron of the stoker, comparatively low combustion rates with a minimum of fuel bed disturbance is essential. Water cooling of the stoker tuyeres seems beneficial, although this coal can be burned on air-cooled machines successfully. I understand that it works well on traveling grate stokers, there being sufficient ash to keep the grates from burning. Combustion rates should not exceed about 40 lb per sq ft per hr, and the usual "no air" rear section should be used for a well-burned-out ash.

Some Observations on Increased Stress Allowance for Boilers

SINCE the recent action of the Boiler Code Committee in permitting an increased stress allowance of 25 per cent, as applied to the pressure parts of power boilers, many questions have arisen on the part of users as to its scope and how it may affect particular cases. Therefore, a reiteration of the Committee's special ruling, together with some general observations, may assist in clarifying the situation in the minds of COMBUSTION readers.

It will be recalled that this action resulted from the present necessity of conserving critical materials, as is now being widely urged by the War Production Board in all fields. In taking this step the Boiler Code Committee, which represents the combined viewpoints and experience of designers, insurers, enforcement bodies and users, gave full consideration to the improvements in design and fabrication methods, advances in metallurgy, in welding and means for examination, as well as enlightened operating practice, since the factor of five was prescribed many years ago. After carefully reviewing all aspects of the situation it apparently was satisfied that an increase of 25 per cent in stress allowance, together with certain additional safeguards, was warranted at this time.

The new ruling applies to all *new* power boilers, whether riveted or welded, regardless of type, that are now under construction, being designed or future boilers, until revisions or new interpretations, if any, are made. However, the allowable pressure in fire-tube boilers, subject to collapsing pressures, has not been changed.

Very few of the states operating under the Code require legislative action in such matters as this, and in most of the states the enforcement bodies have authority to accept interpretations of the Boiler Code Committee. Furthermore, at the present time practically all new boilers are directly or indirectly concerned with war work.

The special ruling by the A.S.M.E. Boiler Code Committee on June 19, pertaining to Case 968, covers a number of questions that may arise concerning the new factor of safety, and is as follows:

SPECIAL RULING

Case No. 968

Inquiry: Due to the present need for conserving critical materials, and the improvements in design, construction, and materials, may the design stresses for power-boiler pressure parts and the joint efficiency in fusion-welded construction be increased over present Code requirements?

Reply: It is the opinion of the Committee that drums and headers of power boilers may be constructed with maximum design stresses given in Table P-7 multiplied by 1.25 up to a temperature of 750 F, inclusive, and a welded joint efficiency of 95 per cent may be used in the formulas in Pars. P-180, P-195 and P-268 with the following restrictions:

(1) The calculated thickness, using the 25 per cent increased design stresses, includes an allowance for stress concentration and thinning of sections by corrosion or other causes, to a limited extent. After calculating the required thickness of shells and heads for boiler drums, using the increased design stresses permitted by this Case, an additive thickness of 0.1 in. shall be included for thicknesses of 0.4 in. and over. Below a thickness of 0.4 in., the additive thickness shall be one quarter of the calculated thickness.

(2) Excessive stress concentration due to sharp reentrant angles or abrupt changes in section shall be minimized in design.

(3) Stresses due to hydrostatic head alone, and other stresses which appreciably increase the average stress over substantial sections of shell or head above the allowable design stress, shall also be considered in determining the thicknesses used in construction.

(4) Large temperature differentials in heads or shells shall be avoided or the effect reduced by shields or other suitable means.

(5) These increased design stresses may be used only for hemispherical or ellipsoidal heads. Dished heads, other than hemispherical or ellipsoidal, designed in accordance with the present Code rules, may be used with shells which are constructed in accordance with the rules of this Case.

(6) Openings in the shell requiring reinforcement under Par. P-268 shall have the reinforcement applied uniformly on the inside and outside of the shell. If not so applied, the amount of reinforcement shall be calculated for a required shell thickness using design stresses from Table P-7. Openings in the heads may have reinforcement on the outside only.

(7) All stays, braces, and parts requiring staying shall be calculated by the present rules.

The maximum allowable working pressure for tubes for water-tube boilers as given in Table P-2, and by the formulas with Table P-2, may be increased by multiplying the values by 1.25 for temperatures up to 750 F, inclusive. For tubes complying with Specifications S-17, S-32 grades A and B, and S-40 only, 30 lb per sq in. shall be deducted from the pressure so determined.

Boilers constructed in accordance with the requirements of this Case and other applicable Code rules are considered safe and shall be stamped in accordance with Par. P-332, the Code symbol stamp to be followed by the letters "NE" which also shall be shown on the manufacturers' data report.

This Case shall be effective until it is annulled, revised, or Code revisions made.

Comments

Hydrostatic head, as referred to in Paragraph 3, does not apply to tubes or headers.

Larger temperature differentials, as referred to in Paragraph 4, means that the outside of drums and drum heads should be covered, and bare sections of drums exposed to fire, where the temperature differential can be greater in the case of thick plates, are to be protected from the heat of the flame.

Where the allowable stress of 1.25 times that in the existing tables, plus 0.1 in., is used for heads, the reinforcements can be placed outside of the head. Also, manhole openings must be either reinforced with a flat plate or ring, the flanged-in manhole not being allowed. On the shell portion of the drums, where this increased stress allowance is used, the reinforcement must be equal both inside and outside.

On boiler tubes, due to the fact that 30 lb is deducted from the allowable working pressure after figuring according to the existing formula times 1.25, it is not necessary to take into consideration the hydraulic head.

It will be noted that the new ruling applies only to certain pressure parts and does not affect other parts, particularly those subjected to steam temperatures over

750 F; nor does it apply to valves and fittings. Square headers, sectional headers or other shapes, the strength of which is determined by hydrostatic deformation test, are to be used in accordance with the previously existing rules and are not to be decreased in thickness. Also, there is an additive thickness to compensate for corrosion and stress concentrations, as well as certain allowances for hydrostatic head. Therefore, the total saving in critical materials will be somewhat below that which might at first seem apparent through the increased stress allowance.

Despite this, the saving is likely to represent an appreciable contribution to the present effort toward making the present limited supply of such materials as effective as possible. It is an effort to which all will subscribe in so far as it may be consistent with safe practice, as determined by experience and the best engineering opinion.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Axial-Flow Fans

The B. F. Sturtevant Company has just issued an attractive 8-page catalog (460) announcing its new line of Victory Axiflo Fans. This fan will be available to industry after the war, as present deliveries are restricted to the U. S. Navy. Pressures range from 1/2 in. to 6 in. of water for motor-driven ventilating fans (adapted to 1160 and 1750 standard speed motors); turbine-driven units operate against pressures as high as 60 in. and at speeds as high as 5000 rpm.

Coal Storage

A 12-page pamphlet entitled "Quantity Storage of Bituminous Coal" by Joseph Harrington has been issued by the Northern Illinois Coal Corporation, the Sunlight Coal Company and the Tecumseh Coal Corporation, and comprises an authoritative statement of the principles involved and necessary safeguards to be taken when coal is to be stored in large quantities.

Control and Measuring Instruments

Wheelco Instrument Company has issued a 16-page illustrated bulletin (No. Z6000) which contains a condensed listing of the company's principal control and measuring instruments. Two pages are devoted to Flame-otrol, a combustion safeguard device for furnaces, boilers and commercial and industrial ovens, while similar treatment is given the company's remote "all purpose" controller. Applications of the latter instrument include boiler feedwater control.

Spectrum Chart

Of special interest to teachers of physics, chemistry and electrical engineering, and to practicing engineers and scientists, is a new seven-color wall chart of the entire electromagnetic spectrum recently published by the Westinghouse Research Laboratories. Approximately 30 by 40 inches in size, the chart is printed on heavy white cloth, and is bound at top and bottom in 3/8-inch black-enameled wooden rods with metal rings attached for convenient hanging.

Every part of the electromagnetic spectrum, of practical significance, is analyzed in detail. Emphasis is placed on uses of each kind of radiation. Spectral terms are carefully and simply defined in a special glossary.

Each chart is packed in a substantial, closed cardboard tube, and is sent postpaid. The price is $2.00. Orders should be sent to Publications Section, 6-N-17, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Centrifugal Pump Performance

An elementary analysis of centrifugal pump performance was presented in a 4-page article by H. Gartmann in the April issue of *Machine Design*, and a reprint of this article is now being distributed by the De Laval Steam Turbine Company. The influence of blade angles and of the areas of wheel passages upon the head-capacity curve is explained by means of simple diagrams and it shows how, once the characteristic curves of a given pump at a certain speed are known, it is possible to predict delivery, head and power requirements and efficiency at a different speed.

Electric Power Systems

General Electric Company has issued a small 24-page booklet (GED-1006) giving valuable suggestions regarding electric power systems for new plants and plant extensions. The load-center system and standardized equipment are offered as the key to saving months of time and tons of vital materials. The booklet is profusely illustrated and typical specifications are given to cover all the basic equipment for the load-center system.

Pump Instruction Manual

The Quimby Pump Company has issued a new Instruction Manual dealing with the installation, operation and maintenance of stationary pumps. Proper servicing of pumps is emphasized as the best guarantee of long life and constant availability of equipment, and many of the rules given apply equally well to other pumps made by other manufacturers.

Water Conditioning

The D. W. Haering Company has just issued a reprint of a recent article, "Economics of Water Conditioning for Scale and Corrosion Control" by Ray C. Rohrdauz, which appeared in the May 1942 issue of *The Petroleum Engineer*. The subject is discussed with particular reference to the petroleum industry but the article may be interpreted in terms of scale and corrosion control on a much broader industrial basis.

Steam-Jet Ejectors

Worthington Pump and Machinery Corporation has issued a 4-page bulletin (W-205-B5A) describing its line of two-stage condensing steam-jet ejectors. A sectional view accompanied by a list of parts is given, and a dimension drawing and table covers six sizes of the Type CTH Steam-Jet Ejector.

Metal-Enclosed Switchgear

A 12-page bulletin has been issued by the General Electric Company dealing with metal-enclosed switchgear for heavy-duty direct-current service up to 250 volts, 8000 amperes. Illustrations comprise photographic reproductions of switchgear mechanisms and typical installations. Typical dimensions of an enclosed switchgear equipment with MC-5 air circuit-breakers is also given.

Pressure, Vacuum and Compound Gages

The Certified Gauge & Instrument Corporation has just issued a 12-page illustrated bulletin describing its line of pressure, vacuum and compound gages. Specially featured is the "Adjust-a-matic" recalibrating mechanism by means of which it is possible to reset the pointer to zero to correct any drift or set of the Bourdon tube.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Welding Handbook

Published by the American Welding Society

The growing importance of welding as an industrial tool in the construction of ships, tanks, planes, guns, munitions and machinery necessitates the publication of a handbook for general up-to-date information on the subject of welding, and the American Welding Society has met this need by providing an authoritative work of reference on the technical phases of welding. The text is arranged in handbook style; nevertheless the material is in a logical sequence with enough explanatory matter to be used as a textbook in engineering schools or as a reference book in trade schools. The volume covers the physics and metallurgy of welding and the weldability of steels; the welding and allied processes; the materials used; training, inspection and safety; design considerations, the testing of welds, and the applications of welding.

The Welding Handbook represents the work of 270 leading welding experts and the Handbook Committee of the A. W. S. are to be congratulated on the concise yet comprehensive and impartial treatment of the subject matter. The volume is copiously illustrated and contains 1593 pages, including a 9-page index. Bound in green buckram, size 6 × 9. Price $6.00 U. S. A.; $6.50 elsewhere.

Elements of Heat Transfer and Insulation

By Max Jakob and George A. Hawkins

With this new text the authors present the fundamentals of heat transfer in a simple, easily followed manner. Intended primarily as a textbook for the instruction of junior and senior students in engineering it apparently embodies the authors' ideas of presenting this important subject.

The arrangement of the material follows quite generally the conventional presentation. Starting from the concept of Thermal Conductivity, the student is led quickly but easily through Conduction in the Steady and Unsteady States, Dimensional Analysis, Free and Forced Convection, and Radiation, to the application of these methods in combination. This is followed by useful comments on experimental determination of data and correction of heat measurements. The work is concluded by a brief introduction to the relations between heat transfer and fluid friction.

The derivations of many of the principles are clear and easily understood. However, the attempt to adhere strictly to technical considerations may prove confusing to students when exposed later to the methods used by designing engineers. A few of the problems and examples introduce the students to the art of design of heat transfer equipment. More attention to the selection of simplified cases involving actual design problems would have increased the value of the text to the student after he leaves the classroom.

As a reference for the designer the book is useful principally for bare fundamentals. For the complex situations often arising in industrial practice, it will be necessary to resort to more complete works on this subject that are available.

The book comprises 169 pages, bound in dark blue buckram; size 6 × 9¼. Price $2.50.

Heat Transmission (Second Edition)

By William H. McAdams

It has been ten years since the first edition of this well-known book appeared as a text for students and a reference for practicing engineers and designers. Since then much research, improved methods of investigation and many new developments have enriched the knowledge concerning heat transmission. However, because of its breadth of application the results are widely scattered in the technical literature of many fields. Much of this has here been digested and correlated with the fundamentals in a form most useful to the designing engineer. This applies especially to graphical methods.

For convenience, the basic assumptions and general background of the derivations have been divorced from the mathematical presentation and are given in the main text, whereas the mathematical treatment is in fine print. Chapters are devoted to conduction, heating and cooling of solids, radiant heat transmission, dimensional analysis, flow of fluids, heat transfer between fluids and solids, the heating and cooling of fluids inside tubes and outside tubes, condensing vapors, heat transfer to boiling liquids and applications to design. The Appendix contains numerous tables and charts and a very extensive bibliography is included.

The book contains 459 pages, 6 × 9 in. with cloth binding. Price $4.50.

Marine Pipe Covering

By W. W. Godwin

This handbook, just off the press, is the first written for marine pipe coverers and for those who are learning the trade.

The book comprises eight chapters dealing with: Moulded Pipe Covering, Plastic Cements, Curved Block Covering, Flat Block Covering, Canvas Covering, Covering Boilers, Moulded Cork Covering, Hair Felt and Asbestos Rope. Many pages are illustrated. Paragraph headings in bold type make this book of 142 pages one of easy reference. Bound in grey buckram, size 5 × 7¼. Price $2.00.

Metallurgy (Revised Edition)

By Carl G. Johnson

The purpose of this book is to provide the average man with practical information concerning the manufacture and behavior of metals and their alloys. For this reason the physical rather than the chemical aspects of metallurgy are stressed, though the chemistry of metallurgy is also adequately dealt with.

The information given covers such subjects as: the properties of metals and tests to determine their uses; producing iron and steel; important nonferrous alloys; copper and its alloys; heat treatments for steel; surface treatments; alloy on special steels; classification of steels; and powder metallurgy. The volume, which comprises 262 pages, is amply illustrated and should serve as an ideal textbook for trade and technical schools.

Cloth bound, size 5¾ × 8½. Price $2.50.

Plant Protection

By E. A. Schurman

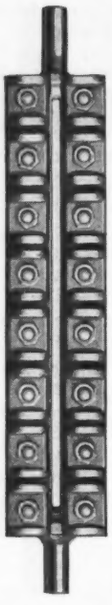
Industrial plant protection has become a specialized branch of modern police science. The essence of the work is prevention rather than investigation of crimes already committed, and the recognized menace of spies, saboteurs and fifth columnists compels established or newly organized police departments to adopt new methods ensuring more adequate security.

The author, E. A. Schurman, Chief of the Protection Department of the Glenn L. Martin Company, is a recognized authority on this subject, and in this book nothing has been recommended which has not survived practical application by organizations whose efficiency of operation is widely known.

The book is illustrated and indexed, and contains 148 pages, size 5 × 7¼. Bound in green buckram. Price $2.00.

Proceedings of the 36th Annual Convention of the Smoke Prevention Association of America

This volume contains in typescript form a report of the proceedings of the 1942 Annual Meeting of the Smoke Prevention Association of America, Inc., held at the Statler Hotel, Cleveland, Ohio, on June 2 to 5, inclusive, together with all the papers read at the convention and the discussions that followed. Among the topics concerned in the various papers were studies of atmospheric pollution, chimney performance, fuel conservation, smoke abatement in wartime and railroad smoke. Many informative charts are given. The book contains 136 pages and is bound in paper covers, size 8½ × 11. Price $1.00 per copy, postage prepaid.



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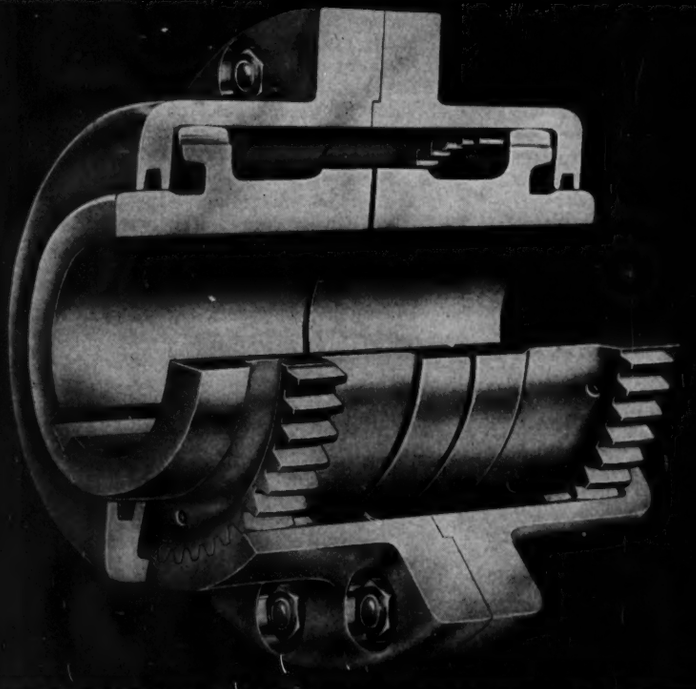

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Program for Joint Fuels Meeting

Plans have been completed for the 1942 Joint Fuels Session of the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division, which is scheduled for September 30 to October 2 at the Statler Hotel, St. Louis, Mo.

The opening session will be addressed by Dr. M. M. Leighton of the Illinois Geological Survey, and A. R. Mumford of Combustion Engineering Company will reply.

Two papers will be presented on Wednesday morning: one by I. M. Roberts, who will discuss "Increasing the Percentage Production of Large Size Coke at Fast Coking Rates to Meet Wartime Demands," and the second, by W. T. Brown, which will deal with "A Plan to Improve Blast-Furnace Coke." The co-chairmen of this session will be Martin A. Mayers and Dr. Frank H. Reed.

In the afternoon there will be three papers, namely: "Density Index Patterns of the Physical Characteristics of Ash and Clinkers From Coal and Admixtures" by R. M. Weimer; "Some Ways to Avoid High Stoker Maintenance and Inefficient Combustion" by A. R. Mumford; and "The Distribution of Coal Dust by Tank Car as Pulverized Fuel" by H. C. Ray. The co-chairmen will be R. A. Sherman and C. T. Hayden.

On Thursday morning, with A. R. Mumford and V. G. Leach acting as co-chairmen, there will be one paper on "Combustion With Coal and Gas Firing" by H. L. Crain and a second on "Use of Mixtures of Oil and Coal in Boiler Furnaces" by Dr. W. C. Schroeder. That afternoon there will be papers on "Priorities in Mine Supplies" by D. L. McElroy, "Meeting Wartime Fuel Problems" by Ollison Craig, and "Using Machine Shops for War Production" by A. L. Barrett. The co-chairmen at this session will be A. W. Thorson and W. Voskuil.

Several luncheon meetings are scheduled and the Percy Nicholls Award presentation will take place at a dinner on Wednesday evening with A. R. Mumford as chairman, J. E. Tobey as toastmaster, and Eugene McAuliffe making the presentation. The recipient of the award has not yet been announced.

It is expected that Secretary Harold L. Ickes will be the guest speaker at the regional meeting banquet on Thursday evening.

Further Government Aid to Students

Chairman McNutt of the War Manpower Commission has announced that the loan fund of five million dollars voted by Congress to help college students speed up their training for technical and professional jobs will soon be available. Under the plan, as worked out, monthly loans totaling not more than $500 a year, at 2½ per cent interest annually and cancelled if the student is drafted during training, will be made to students pursuing courses in engineering, physics, chemistry, medicine, dentistry, pharmacy or veterinary, who are within two years of completing their work. Moreover, these loans will be available only to those registered in accelerated programs in degree-granting colleges and universities. The loans will be made through the medium of the schools concerned upon estimates submitted to the government by each. The student must agree in writing not only to continue in the accelerated program in his particular field but also to engage for the duration of the war in such employment as may be assigned to him by agencies of the Manpower Commission. Also, he must continue to maintain satisfactory standards of scholarship and must be in need of assistance.

Coal Stocks and June Production of Electricity

The Federal Power Commission reports that the coal stocks of electric utility power plants as of July 1 were the highest in history, being 63.3 per cent over those of the same date last year. Of the total coal consumed by such plants during June, 5,200,282 tons were bituminous, an increase of 1.9 per cent over the preceding month; 230,896 tons were anthracite, an increase of 1.2 per cent over May; fuel oil decreased 1.5 per cent and gas increased 5.9 per cent. The June 1942 production of electricity was 14,940,553,000 kwhr, an increase of 11.2 per cent over that for June 1941, and the total installed capacity on June 30, 1942, was 45,336,793 kw, which represented a net increase of 147,609 kw during that month. Production by water power amounted to 35.7 per cent of the total.

WPB Amends Order Affecting Power Equipment

The War Production Board has amended its Limitation Order L-117 so that contractors engaged in the construction of industrial plants may obtain delivery of heavy power and steam equipment to be used in such plants by extending preference rating certificates on orders issued to the persons for whom such plants are being constructed. Heretofore, this order permitted heavy power and steam equipment to be delivered only to the person to whom a preference rating certificate or order was originally issued.

New Motors for War Use Only

The War Production Board has announced that henceforth new motors will be released only for the most important war plants and civilian requirements and that other applicants will have to adapt used equipment to their needs. Ninety per cent of all new electric motors are being tagged for the Army, Navy, Maritime Commission and those war plants producing the most urgent equipment. Owners of all motors available for sale are being asked to register them with the Used Equipment Section of WPB.

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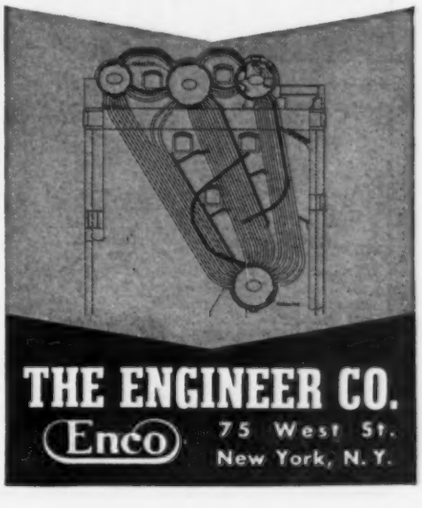

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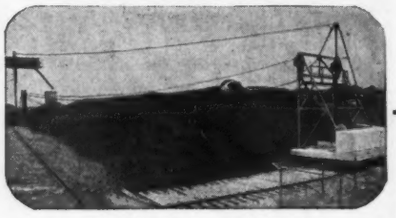

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Obituaries

Arthur Ginn, Associate Sales Manager of the New York District Office of Combustion Engineering Company, Inc., passed away suddenly on July 18 at Ogunquit, Maine, where he had been vacationing.

Mr. Ginn joined the sales force of the Company in 1918 and represented it in upper New York State where he enjoyed a wide acquaintance among utility and industrial power engineers.

He resided in Scarsdale and was a member of the New York, Boston and Rochester Engineers' Clubs as well as several fraternal organizations. Funeral services were held in Trinity Church, Boston, on July 21. Surviving are his wife, Alice D. Ginn, a brother and a sister.

Henry G. Reist, formerly head of the motor and generating engineering department of the General Electric Company and who retired from that position in 1931, died at Schenectady on July 5.

Mr. Reist joined the Thomson-Houston Electric Company, one of the predecessors of General Electric Company, in 1889, shortly after graduation from Lehigh University. For many years he had been active in both the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, having at one time served as a vice-president of the latter.

John C. Hays, Executive Vice-President of Stone & Webster Engineering Corporation, died in New York on July 21. A native of California, his early engineering experience was associated with West Coast hydroelectric construction until 1919 when he joined Stone & Webster as a hydraulic engineer. Becoming a vice-president in 1929 he was made Executive Vice-President in 1938. He was a member of the A.S.M.E., the A.I.E.E. and the A.S.C.E.

Personal

Herbert B. Reynolds, for some years past mechanical engineer in charge of power stations of the Interborough Rapid Transit Company, New York, has recently been promoted to the position of Superintendent of Motive Power of the I.R.T. Division of the New York City Transit System.

S. H. Mortensen, for the last ten years in charge of alternating-current design for the Allis-Chalmers Mfg. Co., has been appointed Chief Electrical Engineer of that company.

R. S. Neblett, Assistant Manager of the General Electric Company's turbine division, has recently been appointed to a position with the Navy's Bureau of Ships where he will be engaged in expediting the manufacture and delivery of geared-turbine propulsion sets.

Herbert S. Marks has been appointed Acting Director of the WPB Power Branch filling the vacancy caused by the transfer of J. A. Krug, former chief of that branch, to the position of Deputy Director General for Priorities Control. Previous to this assignment Mr. Marks served as counsel of the Power Branch of WPB and before that had been with the trustees of the Associated Gas & Electric Corporation.

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